HGCA

PROJECT REPORT No. 250
(INCLUDING ANNEX)

EFFECT ON YIELD AND QUALITY OF STROBILURIN APPLICATIONS TO SPRING MALTING BARLEY

MAY 2002

Price £7.25

PROJECT REPORT No. 250

EFFECT ON YIELD AND QUALITY OF STROBILURIN APPLICATIONS TO SPRING MALTING BARLEY

by

R.B. OVERTHROW

Arable Research Centres, Manor Farm, Daglingworth, Cirencester, Gloucestershire GL7 7AH

This is the final report of a four year project which started in February 1998. The work was funded by a grant of £76,687 from HGCA (project no.1566).

Contents

Abstract

The influence of strobilurin fungicide programmes on the response to increasing levels of nitrogen fertiliser was evaluated, in terms of yield and grain quality for malt production. Trials were conducted at four locations over three years. Fungicide sprays containing low dose mixtures of Opus (epoxiconazole) plus Corbel (fenpropimorph) were applied twice, at GS 30 and GS 45-49. This 'conventional' programme was evaluated alongside strobilurin programmes, where the spray mixtures in the conventional programme were supplemented by full and half recommended rates of Amistar (azoxystrobin) or Ensign (kresoxim methyl plus fenpropimorph), at each fungicide timing. Together with an untreated control, this gave six fungicide treatments, which were applied across each of four levels of applied nitrogen, 75, 100, 125 and 150 kg/ha.

The shape of the nitrogen response curve was not influenced by fungicide chemistry. However yields were consistently higher where strobilurin fungicides were used, whilst still increasing as nitrogen dose increased. Full rate strobilurins in each spray gave higher yields than half rates, but full rates were not cost-effective, whether compared to the half rate, or the conventional programmes. The higher yields achieved with strobilurin fungicides did not lead to an increase in grain nitrogen levels. Where the overall grain nitrogen levels in a trial were low, conventional and strobilurin programmes produced similar levels. Where they were high, the higher yields achieved with strobilurins diluted the grain N, resulting in lower levels with these programmes. Strobilurins therefore reduced grain N from excessively high levels, and have little or no influence when levels were inherently low. This allowed the use of higher levels of nitrogen fertiliser than have been traditionally associated with a malt spring barley crop, without the risk of producing excessively high grain nitrogen content. At all trial sites, over three years the most cost-effective treatments involved two sprays based on half rates of Amistar, with 150 kg/ha applied N. However, the requirement for grain nitrogen levels in a certain band, rather than as low as possible, for most of the UK market, means that excessively low grain nitrogen may not be acceptable for a malt quality sample. Where applied nitrogen levels were kept low, the use of strobilurins on occasion reduced the grain nitrogen below the minimum level assumed for this project (1.6%). Nitrogen level therefore needed to be kept reasonably high where strobilurins were used, in order to reach the required grain nitrogen level. Specific weights, and screenings, were improved by fungicide treatment, but only in some cases was there a greater improvement from strobilurins than from conventional fungicides.

Summary

Introduction

This project aimed to evaluate the effects of strobilurin fungicides on the spring malting barley crop, specifically their effects on yield and grain quality.
The requirement for limited nitrogen levels in the grain of malting barley means that there are restrictions on the amount of nitrogen fertiliser that can be applied, leading to restrictions in yield potential. Nitrogen has traditionally been the only 'yield building' input, with other inputs simply protecting yield, or limiting yield loss.
However, the advent of new fungicide technology, in the form of strobilurin fungicides, has offered a potential means of overcoming this limitation. Strobilurins are thought to exert physiological effects on the crop, independent of their observed disease control effects, and ultimately increase yield. If such effects can be seen in the barley crop, then strobilurins could represent a means of increasing the yield of the crop without adversely influencing the nitrogen balance.

The aim of this project was to assess the influence of strobilurin fungicide programmes on the yield of spring malting barley. In particular, the aim was to determine whether the productivity of the crop could be improved using a combination of a low level of nitrogen fertiliser, to achieve the required grain nitrogen level, and strobilurin fungicides to increase the yield, resulting in a high yielding crop with good grain quality for the malting market.

Also, the project assessed the effects of strobilurin fungicides themselves on grain quality, more specifically whether the use of this chemistry on the spring barley crop required an adjustment in nitrogen management. This is particularly important since, in recent years, the market requirements for malting barley have changed, with the export market becoming more significant and its preference for higher grain nitrogen levels influencing the malting barley standards in the UK.

In summary, the objectives of the project were to

- measure the yield response in spring barley to strobilurin fungicides, over that achieved with 'conventional' (triazole/morpholine) fungicides.
- assess what extra yield could be achieved with strobilurins whilst restricting the level of applied nitrogen fertiliser to that required for optimum grain nitrogen.
- measure any other interactions between strobilurin fungicide programmes and applied nitrogen, and consequently any adjustments in nitrogen management necessary to maintain optimum quality.
- assess the cost-effectiveness of strobilurin fungicide programmes in relation to their effects on grain quality.

Methods

Field trials

In each of the three years 1998, 1999, and 2000, field trials were sown, with the spring barley variety Optic, at each of four locations in England, all in areas associated with malting barley production. These were:

Caythorpe, near Grantham, Lincolnshire - 343a Elmton (brashy calcareous loam over limestone)
Morley, near Wymondham, Norfolk - 572q Ashley (sandy loam over chalky boulder clay)
Andover, Hampshire - 343h Andover (shallow calcareous soil over chalk)
Cirencester, Gloucestershire - 343a Elmton (brashy calcareous loam over limestone)

All trials were sown between early February and early March, at a seed rate appropriate to the area (between 350 and 450 seeds/m^2).

Experimental treatments

The trials involved a total of 24 treatments. Individual treatments involved a combination of nitrogen fertiliser quantity and fungicide programme. The four nitrogen levels were 75, 100, 125, and 150 kg/ha N, all applied as a single dose soon after emergence. Six two-spray fungicide programmes were applied to each N level, as follows:

1. Untreated control
2. Opus 0.25 l/ha + Corbel 0.28 l/ha*
3. As 2, plus Amistar 1.0 l/ha
4. As 2, plus Amistar 0.5 l/ha
5. Opus 0.25 l/ha + Corbel 0.14 l/ha* + Ensign 0.7 l/ha
6. As 2, plus Ensign 0.35 l/ha

All fungicide treatments applied twice, at GS 30 and GS 45-49
Opus contains epoxiconazole (125 g/l). Corbel contains fenpropimorph (750 g/l). Amistar contains azoxystrobin (250 g/l). Ensign contains kresoxim-methyl (150 g/l) plus fenpropimorph (300 g/l).

*Corbel rate adjusted to account for the fenpropimorph content of Ensign

The treatment combinations therefore give a nitrogen response curve, from 75 to 150 kg/ha, for each of the six fungicide programmes.

The conventional fungicide programme in treatment 2 was included in all other programmes (except the untreated control) in order to provide control of disease. The aim of this project was to record the yield-enhancing properties of strobilurins, rather than their disease control, and so it was important to remove the element of disease control from this part of the experiment. (Arable Research Centres' trials on spring barley have shown it possible to keep the crop relatively free of disease with two-spray programmes of low doses of triazole and morpholine).

By adjusting the rate of Corbel the amount of fenpropimorph applied in each programme was constant, such that the only difference between treatments was the level of strobilurin, either azoxystrobin or kresoxim-methyl.

Assessments

For each trial, assessments were made of the following:

1. Disease levels following application of the fungicide programmes
2. Grain yield
3. Specific weight
4. Grain nitrogen content
5. Screenings (% grain retained over a 2.5mm sieve)

Results

Yield and grain quality

The following tables give the yields and grain nitrogen levels for each of the 24 nitrogen/fungicide combinations, expressed as a four-site mean (three-site in 2000) for each year of the project.

Four-site mean for yields and grain nitrogen – 1998

	Yields t/ha				**% grain nitrogen**			
Applied nitrogen:	**75kg N**	**100 kg**	**125 kg**	**150 kg**	**75 kg**	**100 kg**	**125 kg**	**150 kg**
F programme:								
1.Untreated (c)	4.78	4.93	5.19	5.26	1.57	1.65	1.8	1.88
2.Opus + Corbel	5.67	6.09	6.15	6.4	1.64	1.63	1.7	1.81
3.+Amistar 1.0 l/ha	6.46	7.12	7.26	7.43	1.44	1.55	1.56	1.68
4.+Amistar 0.5 l/ha	6.4	6.84	7.23	7.34	1.43	1.57	1.51	1.64
5.+Ensign 0.7 l/ha	6.39	6.71	7.15	7.21	1.48	1.64	1.66	1.78
6.+Ensign 0.35 l/ha	6.23	6.63	6.87	7.06	1.47	1.56	1.64	1.67

Despite the higher yields produced by the strobilurin programmes, the nitrogen response curve continues to climb towards an optimum at 150 kg/ha with all fungicide programmes. The grain nitrogen levels, however, are not increased by the use of strobilurins in the same way that increased applied N raises them. In fact the extra yield from the strobilurins appears to have reduced grain N levels, presumably through a dilution effect. Of the four trial sites, this was more apparent where the inherent grain nitrogen level was high, e.g. in the Cirencester trial, and less so where the grain N level was lower throughout, e.g. at Andover. This effectively means that the use of strobilurin fungicides has raised the yield of the crop, without affecting grain nitrogen except where this was inherently high. In this case the strobilurin programmes caused a reduction in grain N to more acceptable levels.

The use of strobilurins therefore allowed higher levels of nitrogen to be applied, thereby further increasing yield, without compromising grain quality. As an example, the figures above show that using a half-rate Amistar (with Opus and Corbel) and 150 kg/ha produced a grain nitrogen level of 1.64%. To achieve this with the conventional (non-strobilurin) programme, applied N had to be restricted to 100 kg/ha, giving a yield penalty of 1.25 t/ha compared to the Amistar programme.

Four-site mean for yields and grain nitrogen-1999

	Yield t/ha				**% grain N**			
Applied nitrogen:	**75kg N**	**100 kg**	**125 kg**	**150 kg**	**75 kgN**	**100 kg**	**125 kg**	**150 kg**
F programme:								
1.Untreated (c)	5.06	5.24	5.33	5.14	1.33	1.40	1.45	1.57
2.Opus + Corbel	5.77	6.06	6.38	6.79	1.32	1.36	1.42	1.50
3.+Amistar 1.0 l/ha	6.14	6.63	7.14	7.43	1.35	1.36	1.43	1.49
4.+Amistar 0.5 l/ha	5.94	6.67	7.02	7.42	1.31	1.38	1.45	1.51
5.+Ensign 0.7 l/ha	5.95	6.20	7.15	7.34	1.33	1.35	1.41	1.51
6.+Ensign 0.35 l/ha	6.02	6.40	6.94	7.17	1.34	1.36	1.47	1.52

At nitrogen levels of 100 kg/ha and above, the strobilurin fungicide programmes have produced higher yields than the conventional programme. However there was little difference between the strobilurin programmes themselves. With all programmes yields increase with increased applied N, as does grain nitrogen. However, as in 1998, there is no evidence that the higher yields seen with the strobilurin programmes have caused an increase in grain nitrogen. The general reductions in grain N seen in 1998 have not been seen in these trials, however, as all four sites were 'low grain N sites', and in such cases, as seen in some sites in 1998, there is less scope for further reductions through grain N 'dilution'.

Nevertheless the data does illustrate once again that the extra yield achievable with strobilurin fungicides does not necessarily compromise grain quality.

Three-site mean for yields and grain nitrogen-2000

Note: results from Cirencester in 2000 were excessively variable, and are not included.

	Yield t/ha				**% grain nitrogen**			
Applied nitrogen:	**75kg N**	**100 kg**	**125 kg**	**150 kg**	**75 kg**	**100 kg**	**125 kg**	**150 kg**
F programme:								
1.Untreated (c)	5.30	5.59	5.52	5.58	1.40	1.47	1.56	1.70
2.Opus + Corbel	5.99	6.49	6.52	6.71	1.43	1.42	1.48	1.68
3.+Amistar 1.0 l/ha	6.48	7.04	7.32	7.47	1.38	1.46	1.48	1.61
4.+Amistar 0.5 l/ha	6.39	6.99	7.13	7.29	1.40	1.46	1.46	1.61
5.+Ensign 0.7 l/ha	6.16	6.76	7.07	7.31	1.34	1.44	1.54	1.63
6.+Ensign 0.35 l/ha	6.41	6.75	7.07	7.13	1.38	1.45	1.50	1.57

Strobilurin programmes have again produced consistently higher yields than the conventional programme in 2000, as in previous years. The Amistar programmes have tended to give higher yields than the Ensign programmes, though the effect is not consistent across all applied N levels. With these higher yields, the strobilurin programmes have shown evidence of reduction in grain nitrogen, though this is not apparent for all applied N treatments, and with most sites having once more a low 'background' grain N, this effect is smaller than was seen in 1998.

Net margin analysis

The cost benefit calculations in this report make the following assumptions on grain price relative to grain quality, following discussions with the Maltsters Association of Great Britain:

Grain nitrogen 1.6-1.85% - feed barley price plus malting premium

Below 1.6%, or above 1.85% - feed price only.

This is taken as a typical feed barley price at harvest 2000, i.e. £60/tonne

The malt premium used here is taken as £16/tonne, (though this would vary slightly with market fluctuations).

Whilst it is accepted that there are still markets for low grain nitrogen samples below 1.6%, these are now a small percentage of the market, particularly for growers in England. There is still a significant distilling market in Scotland, which requires low grain nitrogen, nevertheless approximately 60% of the UK market now specifies samples in the range 1.6-1.85%. In most cases it is likely that samples outside this range, above or below it, will be unacceptable as malting barley and will therefore be sold as feed barley.

Therefore, whilst not applicable to the whole UK market, it is felt that these assumptions, and therefore the conclusions based on them, are relevant to a large proportion of UK growers.

In the following tables, the no-fungicide treatment with 75 kg/ha applied nitrogen is taken as the control, with margins calculated relative to this treatment in each case. The figures presented are therefore the margins generated over and above those of this control treatment.
The margins are given as three-year means for each trial site. Figures in bold represent the most cost-effective fungicide/nitrogen combination, based on yield and grain quality.

Andover – 3-year mean

Net margin £/ha

Applied nitrogen:	75kg N	100 kg	125 kg	150 kg
F programme:				
1.Untreated (c)	0.0(c)	15.0	15.4	-15.2
2.Opus + Corbel	10.2	33.0	35.2	59.6
3.+Amistar 1.0 l/ha	-11.1	14.4	31.2	41.6

4.+Amistar 0.5 l/ha	10.6	39.0	47.0	**64.0**
5.+Ensign 0.7 l/ha	-3.5	15.3	24.1	41.2
6.+Ensign 0.35 l/ha	9.7	39.7	53.3	55.4

Caythorpe

Net margin £/ha

Applied nitrogen:	**75kg N**	**100 kg**	**125 kg**	**150 kg**
F programme:				
1.Untreated (c)	0.0(c)	3.2	-2.9	-11.5
2.Opus + Corbel	28.8	35.8	41.6	48.6
3.+Amistar 1.0 l/ha	6.0	18.6	41.9	30.4
4.+Amistar 0.5 l/ha	34.2	48.0	44.6	**66.2**
5.+Ensign 0.7 l/ha	6.9	27.7	33.6	40.0
6.+Ensign 0.35 l/ha	30.6	23.7	46.3	45.8

Morley

Net margin £/ha

Applied nitrogen:	75kg N	100 kg	125 kg	150 kg
F programme:				
1.Untreated (c)	0.0(c)	12.8	2.1	5.4
2.Opus + Corbel	29.8	50.0	46.1	73.9
3.+Amistar 1.0 l/ha	-10.2	23.0	26.7	53.1
4.+Amistar 0.5 l/ha	-2.2	41.2	65.5	**95.2**
5.+Ensign 0.7 l/ha	-28.8	13.0	44.4	69.3
6.+Ensign 0.35 l/ha	8.1	40.5	41.5	86.5

Cirencester (2-yr)

Net margin £/ha

Applied nitrogen:	75kg N	100 kg	125 kg	150 kg
F programme:				
1.Untreated (c)	0.0(c)	-29.8	-11.2	-20.6
2.Opus + Corbel	30.9	30.2	39.9	39.0
3.+Amistar 1.0 l/ha	5.7	57.6	51.3	35.7
4.+Amistar 0.5 l/ha	73.5	78.9	79.3	**95.4**
5.+Ensign 0.7 l/ha	51.3	33.4	63.6	23.3
6.+Ensign 0.35 l/ha	76.2	46.5	73.3	61.3

The low yields from the lower N doses, coupled with the higher cost of strobilurin fungicide programmes, have tended to produce negative margins, i.e. financial losses, from some of the low N treatments. With these, the grain nitrogen would have been low, even without any 'strobilurin effect', and would not have reached malting standards. These treatments therefore produced low yields of lower value feed barley. Margins improved as applied nitrogen was increased, though the full rates of Amistar and Ensign were not always cost-effective. (treatments 3 & 5). With the need for higher grain N levels than in the past, and the potential, if they are likely to be high anyway, for strobilurins to reduce grain N, the most profitable treatments were those with the highest level of applied nitrogen, and the yield benefits of strobilurins are seen in the margins from treatment 4. This treatment, with two sprays incorporating half-rate Amistar, together with 150 kg/ha N, gave the highest margin in all four tables.

The good relative performance from the conventional programme at some sites is not due to any detrimental effects on grain nitrogen from strobilurins, (i.e. excessive reductions), since for all combinations of site and season, the grain N levels were too low to make malt quality in the majority of treatments, even at 150 kg/ha. Generally, Amistar has been the more successful strobilurin product, and with the full rates of strobilurins not always being cost-effective, the conventional programme came a close second to the half-rate Amistar programme at Caythorpe and Andover.

Conclusions and implications

Throughout this project, strobilurin fungicide programmes have consistently given higher yields of spring barley than conventional (triazole/morpholine) programmes, and disease assessments have shown that, for the most part, this was not likely to be due to superior foliar disease control. This yield enhancement from the strobilurin programmes was seen to result in a reduction in grain nitrogen content, particularly where this was relatively high in the grain from the conventional fungicide treatment. However, this effect was much less marked, or even absent, where the grain N level in the conventionally-treated samples were inherently low.

There was therefore a trend for strobilurins to reduce grain nitrogen where this was likely to be excessive, but to have little or no influence on grain nitrogen where it was likely to be low, irrespective of how much nitrogen fertiliser was applied. In 1999, for example, all sites showed grain nitrogen levels around 1.6% or less for even the highest nitrogen treatment (150 kg/ha), and the effects of strobilurins on grain nitrogen levels was far less than in 1998, a ‘higher grain N year’. However they still gave significant yield responses over the conventional programme.

The strobilurin programmes also, on several occasions, gave higher specific weight and lower screenings than the conventional programme.

The danger lies with the use of strobilurins together with low levels of nitrogen fertiliser. There is no longer a requirement for grain nitrogen in malting barley samples to be as low as possible. For much of the UK market, grain with a nitrogen content below 1.6% is unsuitable for the markets it is now being sold into. There needs to be a careful balance between factors that reduce grain nitrogen, and those that can increase it, to achieve the optimum grain nitrogen within the desired range. Strobilurin fungicides combined with low nitrogen fertiliser doses may, and have done so in this project, reduce grain nitrogen too far to be acceptable for the malt market. (However such combinations may be appropriate where more extreme measures are needed to restrict grain nitrogen, for example where growers on heavy soils may be attempting to grow malting barley).

Strobilurin fungicides have, in other work, shown very good disease control in spring barley relative to conventional chemistry, and are likely to be used extensively as a result. With the recent changes in grain quality requirements for the crop, there will be a need to consider carefully how much nitrogen fertiliser is applied, if strobilurin fungicides are to be used. It is likely that more will be needed than has traditionally been used, in order to maintain grain nitrogen at a sufficiently high level. The variety used in this project was Optic, a widely-grown variety but thought to produce inherently low grain N.

Nevertheless the highest nitrogen fertiliser level, 150 kg/ha, was frequently insufficient to bring the grain nitrogen level up to the minimum standard, where strobilurin fungicide programmes were applied.

There is therefore a perceived need, from the results of this project, to increase the amount of nitrogen fertiliser applied to spring barley crops. The highest level of applied nitrogen used, (150 kg/ha) in combination with a strobilurin fungicide programme, was consistently the most cost-effective approach, taking yield and grain quality into account.

If implemented by growers, this will result in higher yields than have been achieved in the past. In particular, growers using strobilurin fungicides should apply more nitrogen than they would have traditionally applied for a malting spring barley crop. In these trials, the 'control' level of N was taken as 75 or 100 kg/ha, however the results showed that 150 kg/ha was not enough in some cases. Whilst there is a danger that in a 'high grain N year' grain nitrogen levels will be higher than typically recorded in this work, strobilurin fungicides represent a means of 'managing' the grain N, and reducing the chances of excessively high levels outside the required range. The use of strobilurins for disease control should also lead to higher yields, and so there is considerable potential for the output of the crop as a whole to increase.

Technical Report

Introduction

The development of the malting barley market, particularly overseas, has led to an increased interest in the crop and a corresponding increase in the area grown. In particular the export market has become more and more significant, and with a preference for spring varieties this market has raised the profile of the spring crop. This in turn has focused on the agronomy of the crop, and the possibilities of increasing productivity.

The requirement for limited nitrogen levels in the grain of malting barley means that there are restrictions on the amount of nitrogen fertiliser that can be applied, leading to restrictions in yield potential. This has been without doubt the major aspect of the agronomy of malting barley, with little opportunity to overcome this limitation. Nitrogen has traditionally been the only 'yield building' input, with other inputs simply protecting yield, or limiting yield loss.

However the advent of new fungicide technology, in the form of strobilurin fungicides, has offered a potential means of overcoming this limitation. Strobilurins are thought to exert physiological effects on the crop, independent of their observed disease control effects, and ultimately increasing yield. If such effects can be seen in the barley crop, then strobilurins could represent a means of increasing the yield of the crop without adversely influencing the nitrogen balance, hence 'non fertiliser yield enhancement'.
There is certainly little argument about their disease control properties on the barley crop. It is inevitable that strobilurins will be used extensively in barley crops generally, and it is therefore important to assess their influence on the grain quality, and overall agronomy, of malting barley.

The aim of this project was to assess the influence of strobilurin fungicide programmes on the yield of malting spring barley. In particular, to determine whether the productivity of the crop could be improved using a combination of a low level of nitrogen fertiliser, to achieve the required grain nitrogen level, and strobilurin fungicides to increase the yield, resulting in a high yielding crop with good grain quality for the malting market.

Also, the project assessed the effects of strobilurin fungicides themselves on grain quality, more specifically whether the use of this chemistry on the spring barley crop required an adjustment in nitrogen management. This is particularly important since, in recent years, the market requirements for malting barley have changed, with the export market becoming more significant and its preference for higher grain nitrogen levels influencing the malting barley standards in the UK. Finding the correct husbandry techniques to satisfy this important market is essential.

In summary, the objectives of the project were to

- measure the yield response in spring barley to strobilurin fungicides, over that achieved with 'conventional' (triazole/morpholine) fungicides.
- assess what extra yield could be achieved with strobilurins whilst restricting the level of applied nitrogen fertiliser to that required for optimum grain nitrogen.
- measure any other interactions between strobilurin fungicide programmes and applied nitrogen, and consequently any adjustments in nitrogen management necessary to maintain optimum quality.
- assess the cost-effectiveness of strobilurin fungicide programmes in relation to their effects on grain quality.

Materials and methods

Field trials

In each of the three years 1998, 1999, and 2000, field trials were sown, with the spring barley variety Optic, at each of four locations in England, all in areas associated with malting barley production. These were:

Caythorpe, near Grantham, Lincolnshire - 343a Elmton (brashy calcareous loam over limestone)
Morley, near Wymondham, Norfolk - 572q Ashley (sandy loam over chalky boulder clay)
Andover, Hampshire - 343h Andover (shallow calcareous soil over chalk)
Cirencester, Gloucestershire - 343a Elmton (brashy calcareous loam over limestone)

All trials were sown between early February and early March, at a seed rate appropriate to the area (between 350 and 450 seeds/m^2).

Experimental treatments

The trials involved a total of 24 treatments. Individual treatments involved a combination of nitrogen fertiliser quantity and fungicide programme. The four nitrogen levels were 75, 100, 125, and 150 kg/ha N, all applied as a single dose soon after emergence. Six two-spray fungicide programmes were applied to each N level, as follows:

1. Untreated control
2. Opus 0.25 l/ha + Corbel 0.28 l/ha*
3. As 2, plus Amistar 1.0 l/ha
4. As 2, plus Amistar 0.5 l/ha
5. As 2, plus Ensign 0.7 l/ha
6. As 2, plus Ensign 0.35 l/ha

All fungicide treatments applied twice, at GS 30 and GS 45-49

Opus contains epoxiconazole (125 g/l). Corbel contains fenpropimorph (750 g/l). Amistar contains azoxystrobin (250 g/l). Ensign contains kresoxim-methyl (150 g/l) plus fenpropimorph (300 g/l).

*Corbel rate adjusted to account for the fenpropimorph content of Ensign.

The treatment combinations therefore give a nitrogen response curve, from 75 to 150 kg/ha, for each of the six fungicide programmes.

The conventional fungicide programme in treatment 2 was included in all other programmes (except the untreated control) in order to provide control of disease. The aim of this project was to record the yield-enhancing properties of strobilurins, rather than their disease control, and so it was important to remove the element of disease control from this part of the experiment. (Arable Research Centres' trials on spring barley have shown it possible to keep the crop relatively free of disease with two-spray programmes of low doses of triazole and morpholine).
By adjusting the rate of Corbel the amount of fenpropimorph applied in each programme was constant, such that the only difference between treatments was the level of strobilurin, either azoxystrobin or kresoxim-methyl.

Assessments

For each trial, assessments were made of the following:

- Disease levels following application of the fungicide programmes
- Grain yield
- Specific weight
- Grain nitrogen content
- Screenings (% grain retained over a 2.5mm sieve)

Results

Notes:
For each of the three years of the project, selected trials are presented and discussed, together with the mean data from all sites in that year. The data from the other trials can be found in Appendix A.

The cost benefit calculations in this report make the following assumptions on grain price relative to grain quality, following discussions with the Maltsters Association of Great Britain:

Grain nitrogen 1.6-1.85% - feed barley price plus malting premium

Below 1.6%, or above 1.85% - feed price only.

This is taken as a typical feed barley price at harvest 2000, i.e. £60/tonne

The malt premium used here is taken as £16/tonne, (though this would vary slightly with market fluctuations).

Whilst it is accepted that there are still markets for low grain nitrogen samples below 1.6%, these are now a small percentage of the market, particularly for growers in England. There is still a significant distilling market in Scotland, which requires low grain nitrogen, nevertheless approximately 60% of the UK market now specifies samples in the range 1.6-1.85%. In most cases it is likely that samples outside this range, above or below it, will be unacceptable as malting barley and will therefore be sold as feed barley.

Therefore, whilst not applicable to the whole UK market, it is felt that these assumptions, and therefore the conclusions based on them, are relevant to a large proportion of UK growers.

1. Effects of fungicide programmes on disease control

(Note: results from the Cirencester trial in 2000 were excessively variable, and are not presented).

This project evaluated effects of fungicides other than disease control, and so was not a fungicide project in the normal sense. Each fungicide treatment included the triazole and morpholine elements included in the conventional fungicide treatment, in order to keep disease to insignificant levels, such that other effects could be assessed. Nevertheless disease assessments were carried out in order to check that disease was kept to low levels, and did not influence the yield and quality differences recorded in the trials.

The following list summarises the disease levels seen in each of the trials.

Andover

1998: Untreated plots showed up to 22% *Rhynchosporium secalis*. All fungicide treatments, including the conventional, showed less than 2% of any disease.

1999: Untreated plots showed 15% brown rust, 6-10% *Rhynchosporium.* All fungicide treated plots had <5% infection.

2000: All fungicide programmes showed disease at <5%

Caythorpe

1998: All strobilurin treatments showed disease <5%. The conventional programme was carrying 8-10% brown rust with the higher levels of applied nitrogen.

1999: Only the untreated plots showed assessable levels of disease.

2000: Only untreated plots showed assessable levels of disease.

Cirencester:

1998: *Rhynchosporium* levels were high, with 87% infection on leaf 2 with the conventional programme. Strobilurin programmes reduced this to between 36 and 44%.

1999: *Rhynchosporium* reached 27% on leaf 2 of the untreated plots, and brown rust 12%. All fungicide treated plots showed <5% infection.

Morley:

1998: Untreated plots showed 8-10% brown rust on leaf 2&3, and 24% *Rhynchosporium*. All treated plots had <5% disease on these leaves.

1999: Untreated plots showed <5% disease on all leaves.

2000: Disease on untreated plots reached 9% *Rhynchosporium* infection. The conventional fungicide programme, with 150 kg/ha applied N, showed 7%. All strobilurin programmes reduced this to <2%.

All fungicide programmes therefore held disease levels to less than 5% on any leaf, at the majority of sites. Two sites, Morley in 2000 and Caythorpe in1998, showed disease levels slightly above this threshold where the highest level of applied nitrogen was used. However the one major exception, where the background disease control programme failed, was at Cirencester in 1998. The conventional programme showed high levels of disease, which were considerably reduced by the strobilurin programmes. It is important to note, therefore, that in this one trial, the results were influenced by superior disease control from the strobilurins as well as other effects. This was not the case in the other 10 trials, however.

2. Yields and grain quality

1998

Andover

Table 1. Yields and specific weights, Andover 1998

	Yields t/ha				**Specific weight kg/hl**			
Applied nitrogen:	**75kg N**	**100 kg**	**125 kg**	**150 kg**	**75 kg**	**100 kg**	**125 kg**	**150 kg**
F programme:								
1.Untreated (c)	5.03	5.48	5.80	5.82	66.4	66.6	67.4	68.0
2.Opus + Corbel	5.78	6.72	6.59	6.97	67.6	67.3	67.7	67.8
3.+Amistar 1.0 l/ha	6.58	7.22	7.84	8.13	67.4	68.2	68.9	69.4
4.+Amistar 0.5 l/ha	6.32	7.07	7.72	8.06	67.5	68.2	68.0	69.6
5.+Ensign 0.7 l/ha	6.44	7.06	7.59	7.94	67.1	67.6	67.3	68.9
6.+Ensign 0.35 l/ha	6.13	7.24	7.38	7.78	67.1	67.2	68.2	69.2

LSD (P=0.05) yield: 0.45 specific wt.: 1.0

For each fungicide treatment, yield increases with increased nitrogen dose, peaking at 150 kg/ha in most cases. However for each nitrogen level the yields for the strobilurin fungicide treatments are significantly higher than that for the conventional fungicide programme. Highest yields came from the full-rate Amistar programme. The slope of the nitrogen response curve is therefore similar for both strobilurin and conventional fungicides, but up to 1.2 t/ha higher at each point with strobilurins.
Specific weight also increases with higher applied N. It is also higher with strobilurins, but these differences are only statistically significant at the higher doses of applied nitrogen.

Table 2. Grain nitrogen content and screenings, Andover 1998

	% grain N				**% screenings>2.5mm**			
Applied nitrogen:	**75kg N**	**100 kg**	**125 kg**	**150 kg**	**75 kg**	**100 kg**	**125 kg**	**150 kg**
F programme:								
1.Untreated (c)	1.32	1.40	1.51	1.59	96.6	96.5	95.7	91.6
2.Opus + Corbel	1.32	1.37	1.45	1.63	97.7	97.1	97.4	96.0
3.+Amistar 1.0 l/ha	1.33	1.35	1.38	1.57	98.0	97.7	97.9	97.9
4.+Amistar 0.5 l/ha	1.30	1.34	1.43	1.54	97.9	98.1	97.9	97.8
5.+Ensign 0.7 l/ha	1.32	1.35	1.44	1.58	98.0	97.6	96.7	97.2
6.+Ensign 0.35 l/ha	1.29	1.37	1.47	1.52	97.8	97.8	97.7	98.1

LSD (P=0.05) grain N: 0.11. screenings: 3.0

Grain nitrogen levels increase with increases in applied N, but there are no significant differences between fungicide programmes in this respect. Therefore the strobilurin programmes have increased yield for each level of applied nitrogen, but have not influenced grain N, compared to a conventional fungicide programme.

Screenings are stable across all N levels with fungicide treatment, but are inferior with the higher N levels where no fungicides are applied.

Cirencester

Table 3.Yields and specific weights, Cirencester 1998

	Yields t/ha				Specific weight kg/hl			
Applied nitrogen:	**75kg N**	**100 kg**	**125 kg**	**150 kg**	**75 kg**	**100 kg**	**125 kg**	**150 kg**
F programme:								
1.Untreated (c)	4.13	3.50	4.30	4.41	61.2	59.4	58.7	59.6
2.Opus + Corbel	5.23	5.11	5.27	5.54	62.6	63.2	63.2	62.4
3.+Amistar 1.0 l/ha	6.29	6.88	6.63	6.74	67.2	66.3	66.3	66.1
4.+Amistar 0.5 l/ha	6.49	6.61	6.53	6.55	67.6	67.2	67.9	66.3
5.+Ensign 0.7 l/ha	6.39	6.30	6.64	6.42	66.7	66.5	65.5	65.3
6.+Ensign 0.35 l/ha	6.44	6.13	6.33	6.32	66.5	66.6	67.1	67.1

LSD (P=0.05) yield: 0.56 specific weight: 1.1

Here the peak response to nitrogen is lower, around 100-125 kg/ha for all fungicide treatments. However at each N level all strobilurin programmes significantly outyielded the conventional programme. Again, therefore, the nitrogen response is similar for both conventional and strobilurin fungicides, but at different yield levels, the strobilurins giving yields up to 1.77 t/ha higher than the conventional programme for equivalent N doses. Specific weight is improved by strobilurin fungicides, but less influenced by N dose.

Differential disease control was a factor in this trial, however, with disease reaching high levels with the conventional programme. This was considerably reduced by inclusion of the strobilurins, and this will account for some of these increases in yield and specific weight. See previous section on 'Effects of fungicide treatments on disease control'.

Table 4. Grain nitrogen content and screenings, Cirencester 1998

	% grain N				%screenings>2.5mm			
Applied nitrogen:	**75kg N**	**100 kg**	**125 kg**	**150 kg**	**75 kg**	**100 kg**	**125 kg**	**150 kg**
F programme:								
1.Untreated (c)	2.03	2.07	2.46	2.40	66.3	59.4	52.1	56.3
2.Opus + Corbel	2.40	2.10	2.42	2.27	73.0	76.1	71.8	64.8
3.+Amistar 1.0 l/ha	1.58	1.81	1.82	1.89	93.0	88.9	87.1	85.9
4.+Amistar 0.5 l/ha	1.68	1.85	1.47	1.69	92.0	92.4	90.1	85.2
5.+Ensign 0.7 l/ha	1.68	1.99	2.14	2.27	91.7	89.2	83.2	83.6
6.+Ensign 0.35 l/ha	1.82	1.89	1.95	1.92	90.6	86.6	89.4	88.0

LSD (P=0.05) grain nitrogen: 0.27 screenings: 0.57

Here the background grain nitrogen level is higher, and the large yield responses to strobilurins seen at this site have diluted this high grain N. Amistar has been more effective in this than Ensign. Here, then, the higher yields from strobilurin programmes were associated with influences on grain nitrogen, reducing this from excessively high levels in untreated or conventionally treated plots, down to more acceptable levels for malt production.

Screenings were also very poor for the untreated and conventional treatments. They were improved considerably by the strobilurin programmes, but not always above a 90% threshold.

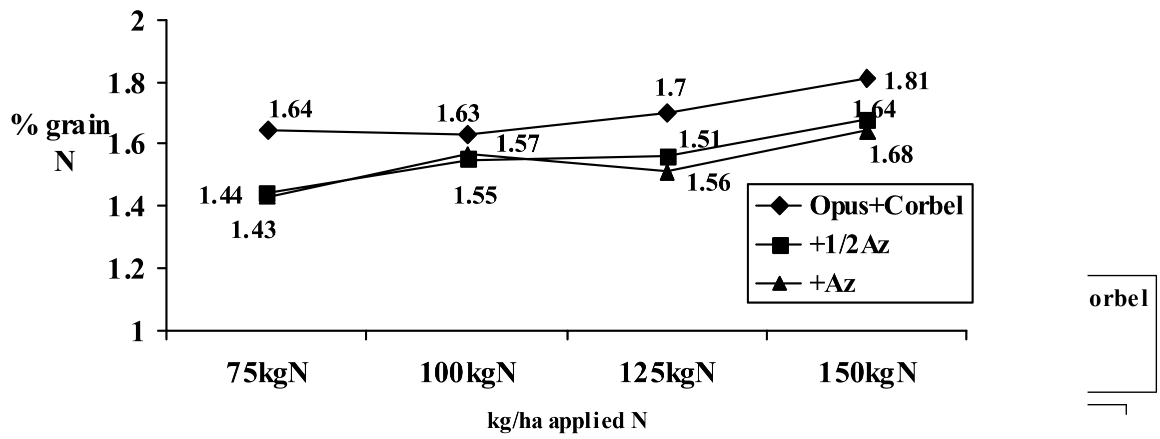
Table 5. Four-site mean for yields and grain nitrogen – 1998

	Yields t/ha				**% grain nitrogen**			
Applied nitrogen:	**75kg N**	**100 kg**	**125 kg**	**150 kg**	**75 kg**	**100 kg**	**125 kg**	**150 kg**
F programme:								
1.Untreated (c)	4.78	4.93	5.19	5.26	1.57	1.65	1.8	1.88
2.Opus + Corbel	5.67	6.09	6.15	6.4	1.64	1.63	1.7	1.81
3.+Amistar 1.0 l/ha	6.46	7.12	7.26	7.43	1.44	1.55	1.56	1.68
4.+Amistar 0.5 l/ha	6.4	6.84	7.23	7.34	1.43	1.57	1.51	1.64
5.+Ensign 0.7 l/ha	6.39	6.71	7.15	7.21	1.48	1.64	1.66	1.78
6.+Ensign 0.35 l/ha	6.23	6.63	6.87	7.06	1.47	1.56	1.64	1.67

Despite the higher yields produced by the strobilurin programmes, the nitrogen response curve continues to climb towards an optimum at 150 kg/ha with all fungicide programmes. The grain nitrogen levels, however, are not increased by the use of strobilurins in the same way that increased applied N raises them. In fact the extra yield from the strobilurins appears to have reduced grain N levels, presumably through a dilution effect. Note this was more apparent where the inherent grain

ni

Figure 2. Influence of strobilurin fungicides on nitrogen response
4 site mean 1998- grain nitrogen



1999

Andover

Table 6. Yields and specific weights, Andover 1999.

	Yields t/ha				**Specific weight kg/hl**			
Applied nitrogen:	**75kg N**	**100 kg**	**125 kg**	**150 kg**	**75 kg**	**100 kg**	**125 kg**	**150 kg**
F programme:								
1.Untreated (c)	4.58	4.84	5.06	4.08	70.1	69.7	70.4	69.4
2.Opus + Corbel	5.04	5.17	5.71	6.22	69.6	69.6	70.1	70.6
3.+Amistar 1.0 l/ha	5.54	6.18	6.52	6.89	69.4	70.0	70.2	71.3
4.+Amistar 0.5 l/ha	5.52	6.23	6.32	6.92	69.0	69.3	70.2	70.8
5.+Ensign 0.7 l/ha	5.48	6.03	6.54	6.80	69.0	69.6	70.4	70.5
6.+Ensign 0.35 l/ha	5.52	5.98	6.34	6.73	69.0	69.7	70.0	70.3

LSD (P=0.05) yield: 0.47 specific weight: 0.80

As in the 1998 trials, the strobilurin programmes (3-6) have given significantly higher yields than the conventional programme (2). However they have still allowed responses to increased nitrogen dose. Within the four strobilurin programmes, there is little difference in yield, indicating that the half-rates were adequate.

Specific weights were not improved by fungicide treatment except at the highest N dose (150 kg/ha), where all fungicide treatments gave significantly higher specific weights than the untreated.

Table 7. Grain nitrogen content and screenings, Andover 1999.

	% grain N				**% screenings >2.5mm**			
Applied nitrogen:	**75kg N**	**100 kg**	**125 kg**	**150 kg**	**75 kg**	**100 kg**	**125 kg**	**150 kg**
F programme:								
1.Untreated (c)	1.35	1.36	1.4	1.52	92.6	91.0	91.5	89.3
2.Opus + Corbel	1.32	1.35	1.41	1.47	93.4	92.8	94.2	94.2
3.+Amistar 1.0 l/ha	1.33	1.38	1.46	1.45	93.0	94.2	94.2	95.5
4.+Amistar 0.5 l/ha	1.32	1.39	1.44	1.49	91.4	94.0	94.1	95.1
5.+Ensign 0.7 l/ha	1.31	1.36	1.4	1.51	93.3	94.1	94.7	95.2
6.+Ensign 0.35 l/ha	1.35	1.38	1.41	1.47	92.9	94.0	94.0	95.0

LSD (P = 0.05) grain N: 0.07 screenings 1.7

As in 1998, the grain N levels at this site were low, and have not been influenced to any great degree by fungicide programme. Only the full rate Amistar programme (3) at 150 kg/ha N, has given a grain N significantly different (lower) than the untreated control.

The screening figures show that all fungicide programmes improved screenings over the untreated control, with no significant differences between the fungicide programmes themselves.

Morley

Table 8. Yields and specific weights, Morley 1999.

	Yields t/ha				Specific weight kg/hl			
Applied nitrogen:	**75kg N**	**100 kg**	**125 kg**	**150 kg**	**75 kg**	**100 kg**	**125 kg**	**150 kg**
F programme:								
1.Untreated (c)	4.93	5.36	5.12	5.43	68.1	68.4	67.3	68.4
2.Opus + Corbel	5.67	5.94	6.25	6.78	69.6	69.2	69.4	69.9
3.+Amistar 1.0 l/ha	6.15	6.27	7.08	7.37	70.0	69.4	71.1	70.0
4.+Amistar 0.5 l/ha	4.93	6.26	7.08	7.34	68.8	69.8	70.5	70.6
5.+Ensign 0.7 l/ha	5.09	6.24	7.19	7.40	68.8	69.9	70.3	70.7
6.+Ensign 0.35 l/ha	5.37	6.14	6.94	7.09	68.7	69.3	70.3	70.7

LSD (P=0.05) yield: 0.40 specific weight: 1.1

With nitrogen doses of 100 kg/ha or above, all fungicide treatments produced significantly higher yields than the untreated control, and with one exception (6, at 150 kg/ha N), all strobilurin programmes significantly outyielded the conventional programme. However at 75 kg/ha applied N, there was less difference between fungicide programmes. All fungicide programmes gave their highest yield with the highest N dose, but statistically most programmes peaked at 125 kg/ha.
At 150 kg/ha applied N, the strobilurin programmes outyielded the conventional programme by between 0.31(NS) and 0.62 t/ha.
Specific weight was generally improved by fungicide treatment, though again this was not the case at 75 kg/ha. There were few differences between conventional and strobilurin treatments, however.

Table 9. Grain nitrogen content and screenings, Morley 1999.

	% grain N				%screenings >2.5mm			
Applied nitrogen:	**75kg N**	**100 kg**	**125 kg**	**150 kg**	**75 kg**	**100 kg**	**125 kg**	**150 kg**
F programme:								
1.Untreated (c)	1.26	1.39	1.37	1.53	96.9	95.8	94.4	95.8
2.Opus + Corbel	1.37	1.32	1.40	1.50	97.2	96.8	96.9	97.3
3.+Amistar 1.0 l/ha	1.39	1.3	1.42	1.43	97.8	96.1	97.5	97.4
4.+Amistar 0.5 l/ha	1.26	1.32	1.38	1.49	97.0	97.8	97.1	97.0
5.+Ensign 0.7 l/ha	1.27	1.32	1.43	1.49	97.4	97.2	97.3	97.4
6.+Ensign 0.35 l/ha	1.31	1.38	1.45	1.54	97.3	97.2	97.5	96.3

LSD (P = 0.05) grain N: 0.12 specific weight: 1.2

At this site also the grain N levels were inherently low, giving little scope for influence by fungicide programme. Increased applied N has increased the grain nitrogen with all programmes, but the higher yields seen with the strobilurin programmes has not been reflected in grain N either positively or negatively, and for each level of applied N there were no significant differences between fungicide treatments for grain nitrogen.

Again, the screenings have been improved by fungicide treatment, but there are no consistent trends for differences between fungicide programmes.

Table 10. Four-site mean for yields and grain nitrogen-1999

	Yield t/ha				% grain N			
Applied nitrogen:	**75kg N**	**100 kg**	**125 kg**	**150 kg**	**75 kgN**	**100 kg**	**125 kg**	**150 kg**
F programme:								
1.Untreated (c)	5.06	5.24	5.33	5.14	1.33	1.40	1.45	1.57
2.Opus + Corbel	5.77	6.06	6.38	6.79	1.32	1.36	1.42	1.50
3.+Amistar 1.0 l/ha	6.14	6.63	7.14	7.43	1.35	1.36	1.43	1.49
4.+Amistar 0.5 l/ha	5.94	6.67	7.02	7.42	1.31	1.38	1.45	1.51
5.+Ensign 0.7 l/ha	5.95	6.20	7.15	7.34	1.33	1.35	1.41	1.51
6.+Ensign 0.35 l/ha	6.02	6.40	6.94	7.17	1.34	1.36	1.47	1.52

At nitrogen levels of 100 kg/ha and above, the strobilurin fungicide programmes have produced higher yields than the conventional programme. However there was little difference between the strobilurin programmes themselves. With all programmes yields increase with increased applied N, as does grain nitrogen. However, as in 1998, there is no evidence that the higher yields seen with the strobilurin programmes have caused an increase in grain nitrogen. The general reductions in grain N seen in 1998 have not been seen in these trials, however, as all four sites were ‘low grain N sites’, and in such cases, as seen in some sites in 1998, there is less scope for further reductions through yield dilution.

Nevertheless the data does illustrate that the extra yield achievable with strobilurin fungicides has not compromised grain quality.

Figure 3. Influence of strobilurin fungicides on nitrogen response
4 site mean 1999 - yield

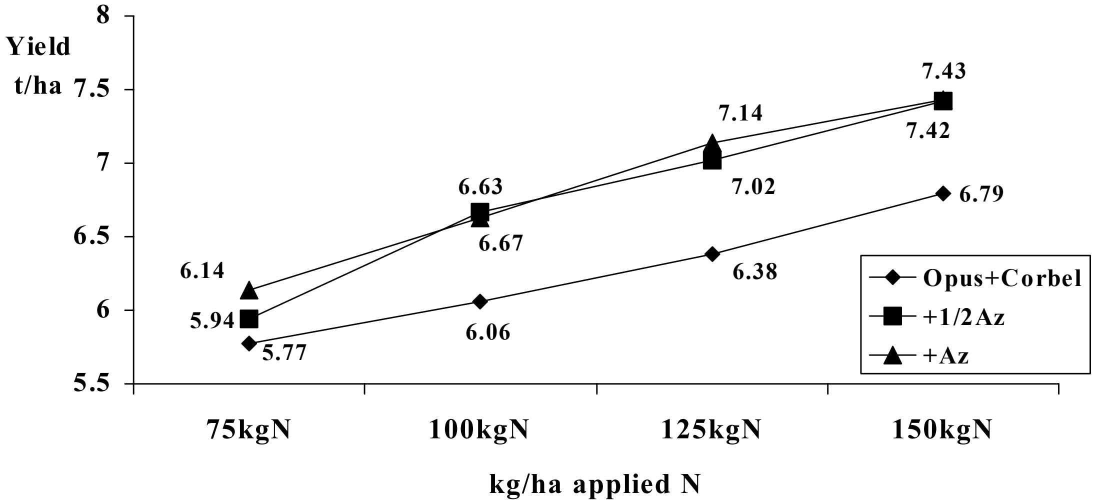
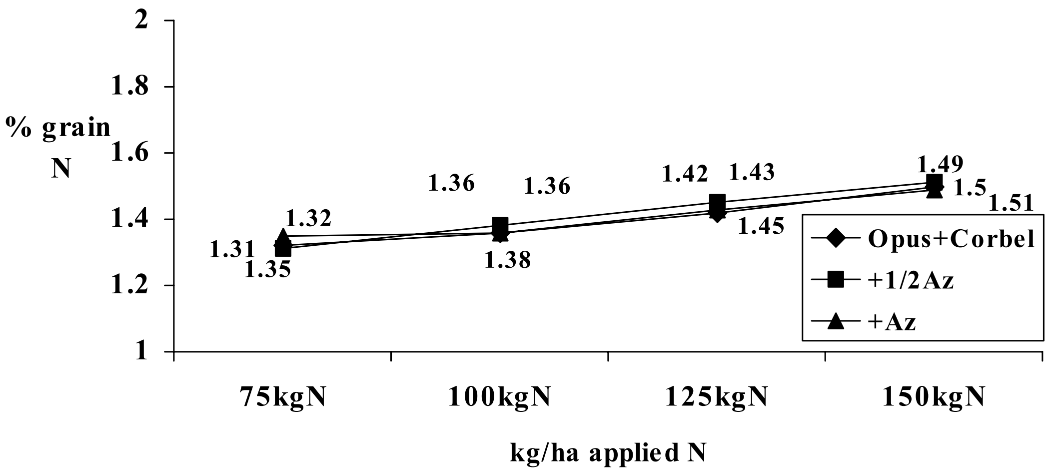


Figure 4. Influence of strobilurin fungicides on nitrogen response
4 site mean 1999- grain nitrogen



2000

Andover

Table 11.Yields and specific weights, Andover 2000.

	Yields t/ha				**Specific weight kg/hl**			
Applied nitrogen:	**75kg N**	**100 kg**	**125 kg**	**150 kg**	**75 kg**	**100 kg**	**125 kg**	**150 kg**
F programme:								
1.Untreated (c)	4.78	5.29	5.24	5.14	62.5	63.4	62.6	63.4
2.Opus + Corbel	5.25	5.76	5.93	6.21	64.4	65.9	66.3	66.1
3.+Amistar 1.0 l/ha	5.85	6.32	6.67	7.00	67.8	67.6	69.2	69.2
4.+Amistar 0.5 l/ha	5.72	6.15	6.28	6.66	65.8	68.0	67.7	69.1
5.+Ensign 0.7 l/ha	5.35	6.03	6.16	6.71	65.3	67.1	67.5	68.3
6.+Ensign 0.35 l/ha	5.59	5.99	6.64	6.41	65.1	66.8	67.3	67.6

LSD (P=0.05) yield: 0.39 specific weight: 1.5

All fungicide programmes outyielded the untreated control, but at 75 and 100 kg/ha applied N, only the two Amistar programmes significantly outyielded the conventional programme. At 125 and 150 kg/ha N, the yield differences between the strobilurin programmes were less consistent.

For specific weight, the treatment effects were clearer. All fungicide programmes gave better specific weight than the untreated, and all strobilurin programmes consistently gave better specific weight than the conventional programme, but these differences were again less clear with the lowest level of applied N.

Table 12. Grain nitrogen content and screenings, Andover 2000

	% grain N				**%screenings >2.5mm**			
Applied nitrogen:	**75kg N**	**100 kg**	**125 kg**	**150 kg**	**75 kg**	**100 kg**	**125 kg**	**150 kg**
F programme:								
1.Untreated (c)	1.24	1.32	1.38	1.59	89.7	88.3	83.3	78.2
2.Opus + Corbel	1.24	1.28	1.31	1.47	94.3	94.4	92.0	87.5
3.+Amistar 1.0 l/ha	1.30	1.36	1.32	1.48	97.3	96.6	96.3	93.2
4.+Amistar 0.5 l/ha	1.27	1.36	1.33	1.45	92.5	96.6	95.5	93.6
5.+Ensign 0.7 l/ha	1.23	1.29	1.48	1.55	95.6	95.5	92.3	92.3
6.+Ensign 0.35 l/ha	1.21	1.37	1.30	1.42	94.8	95.4	94.0	91.4

LSD (P=0.05) grain N: 0.14 screenings: 3.4

Again this site had exceptionally low ‘background’ grain nitrogen levels, only exceeding 1.5% with two of the six treatments at the highest N dose (150 kg/ha). There are still small increases in grain nitrogen with increased applied N, for all treatments, but these are very small, and there is no evidence of any differential effects here between the fungicide programmes.

Screenings were improved by fungicide treatment, but again the differences between fungicide programmes were inconsistent.

Morley

Table 13.Yields and specific weights, Morley 2000.

	Yields t/ha				**Specific weight kg/hl**			
Applied nitrogen:	**75kg N**	**100 kg**	**125 kg**	**150 kg**	**75 kg**	**100 kg**	**125 kg**	**150 kg**
F programme:								
1.Untreated (c)	5.52	5.87	5.74	5.89	68.3	68.4	67.5	67.1
2.Opus + Corbel	6.39	7.10	6.98	7.09	69.0	69.5	69.7	69.4
3.+Amistar 1.0 l/ha	6.37	7.52	7.68	7.98	70.2	70.5	70.6	70.5
4.+Amistar 0.5 l/ha	6.58	7.53	7.87	8.09	69.5	70.6	70.8	70.9
5.+Ensign 0.7 l/ha	6.30	7.12	7.82	7.93	68.8	70.2	70.7	70.4
6.+Ensign 0.35 l/ha	6.86	7.36	7.50	7.77	70.0	69.9	70.5	70.0

LSD (P=0.05) yield: 0.49 specific weight: 0.9

All fungicide programmes gave significantly higher yields than the untreated control, but the strobilurin programmes only consistently outyielded the conventional programmes with the higher doses of applied N. Nevertheless it was these higher N doses which gave the highest yields and so overall the strobilurin programmes were more successful. At these nitrogen levels, however, there were no statistical differences between the strobilurin programmes themselves.

Table 14. Grain nitrogen content and screenings, Morley 2000.

	% grain N				**%screenings >2.5mm**			
Applied nitrogen:	**75kg N**	**100 kg**	**125 kg**	**150 kg**	**75 kg**	**100 kg**	**125 kg**	**150 kg**
F programme:								
1.Untreated (c)	1.39	1.46	1.58	1.66	94.3	92.6	92.4	86.1
2.Opus + Corbel	1.37	1.44	1.48	1.85	96.7	95.9	96.0	93.7
3.+Amistar 1.0 l/ha	1.30	1.42	1.44	1.53	97.1	97.2	97.1	96.7
4.+Amistar 0.5 l/ha	1.33	1.47	1.52	1.66	96.9	96.4	96.9	94.9
5.+Ensign 0.7 l/ha	1.31	1.44	1.50	1.65	96.7	96.8	96.3	96.3
6.+Ensign 0.35 l/ha	1.41	1.42	1.56	1.60	96.8	96.7	95.6	94.8

LSD (P=0.05) grain N: 0.11 screenings: 1.5

Grain nitrogen levels are similar, for a given applied N rate, for each of the fungicide programmes, until the applied N rate reaches 150 kg/ha. Here, the conventional programme produced a grain N level of 1.85%, whilst with the strobilurin programmes it was restricted to 1.66% or less. This shows the same trend, albeit to a lesser degree, seen at Cirencester in 1998, where some of the strobilurin programmes significantly reduced grain nitrogen with the higher levels of applied N.

The screening figures show similar trends to previous trials, with all fungicide programmes improving screenings over the untreated control, but no consistent differences between the fungicide programmes themselves, conventional or strobilurin.

Table 15**. Three-site mean for yields and grain nitrogen-2000**

	Yield t/ha				**% grain nitrogen**			
Applied nitrogen:	**75kg N**	**100 kg**	**125 kg**	**150 kg**	**75 kg**	**100 kg**	**125 kg**	**150 kg**
F programme:								
1.Untreated (c)	5.30	5.59	5.52	5.58	1.40	1.47	1.56	1.70
2.Opus + Corbel	5.99	6.49	6.52	6.71	1.43	1.42	1.48	1.68
3.+Amistar 1.0 l/ha	6.48	7.04	7.32	7.47	1.38	1.46	1.48	1.61
4.+Amistar 0.5 l/ha	6.39	6.99	7.13	7.29	1.40	1.46	1.46	1.61
5.+Ensign 0.7 l/ha	6.16	6.76	7.07	7.31	1.34	1.44	1.54	1.63
6.+Ensign 0.35 l/ha	6.41	6.75	7.07	7.13	1.38	1.45	1.50	1.57

Strobilurin programmes have again produced consistently higher yields than the conventional programme in 2000, as in previous years. The Amistar programmes have tended to give higher yields than the Ensign programmes, though the effect is not consistent across all applied N levels. With these higher yields, the strobilurin programmes have shown evidence of reduction in grain nitrogen, though this is not apparent for all applied N treatments, and with most sites having once more a low ‘background’ grain N, this effect is smaller than was seen in 1998.

Figure 5. Influence of strobilurin fungicides on nitrogen response
3 site mean 2000 - yield

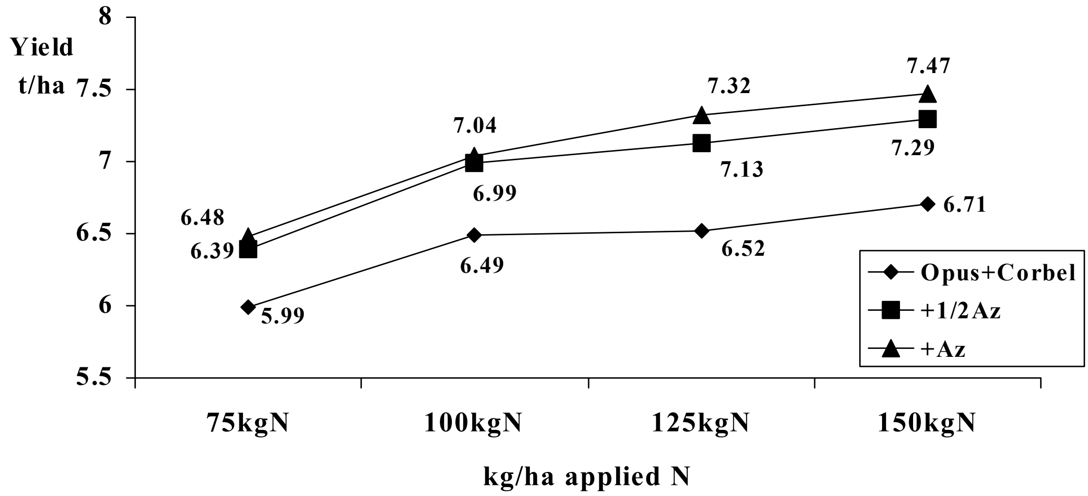
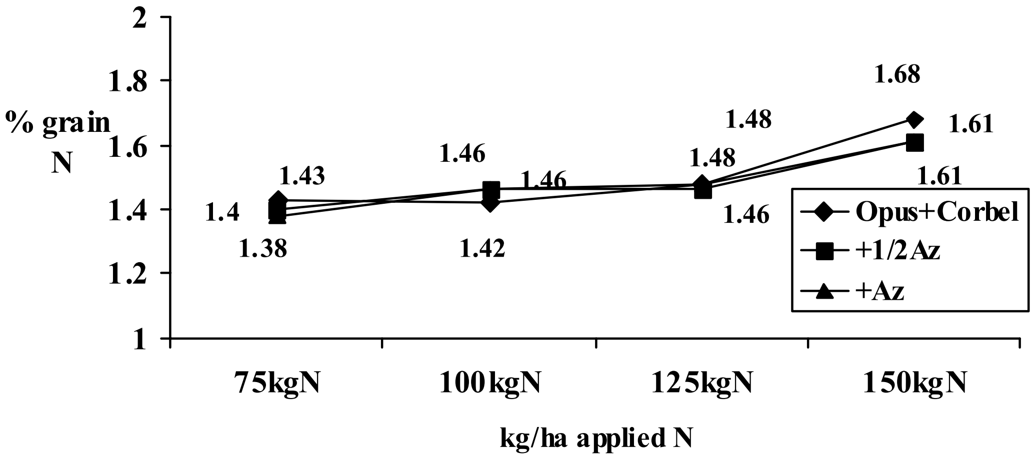


Figure 6. Influence of strobilurin fungicides on nitrogen response
3 site mean 2000- grain nitrogen



3. Net margin analysis

In the following tables, the no-fungicide treatment with 75 kg/ha applied nitrogen is taken as the control, with margins calculated relative to this treatment in each case. The figures presented are therefore the margins generated over and above those of this control treatment.

Please see the notes at the beginning of the results section for further explanation of grain prices used.

The margins are given as three-year means for each trial site. Figures in bold represent the most cost-effective fungicide/nitrogen combination, based on yield and grain quality.

Table 16. **Andover – Net margins (3-year mean)**

Net margin £/ha

Applied nitrogen:	75kg N	100 kg	125 kg	150 kg
F programme:				
1.Untreated	0.0(c)	15.0	15.4	-15.2
2.Opus + Corbel	10.2	33.0	35.2	59.6
3.+Amistar 1.0 l/ha	-11.1	14.4	31.2	41.6
4.+Amistar 0.5 l/ha	10.6	39.0	47.0	**64.0**
5.+Ensign 0.7 l/ha	-3.5	15.3	24.1	41.2
6.+Ensign 0.35 l/ha	9.7	39.7	53.3	55.4

The low yields from the lower N doses, coupled with the higher cost of strobilurin fungicide programmes, have produced negative margins, i.e. financial losses, from some of the low N treatments. With these, the grain nitrogen would have been low, even without any ‘strobilurin effect’, and would not have reached malting standards. These treatments therefore produced low yields of lower value feed barley. Margins improved as applied nitrogen was increased, though the full rates of Amistar and Ensign used at both timings were not cost-effective (treatments 3 & 5) compared to the half rates. With the need for higher grain N levels than in the past, and the potential, if they are likely to be high anyway, for strobilurins to reduce grain N, the most profitable treatments were those with the highest level of applied nitrogen, and the yield benefits of strobilurins are seen in the margin from treatments 4 and 6. These treatments, with two sprays incorporating half rate Amistar or half rate Ensign, gave the highest margins for each N dose, and at 150 kg/ha applied N the half rate Amistar programme was the most profitable treatment in the trial.

Table 17. **Caythorpe – Net margins (3year mean)**

Net margin £/ha

Applied nitrogen:	75kg N	100 kg	125 kg	150 kg
F programme:				
1.Untreated (c)	0.0(c)	3.2	-2.9	-11.5
2.Opus + Corbel	28.8	35.8	41.6	48.6
3.+Amistar 1.0 l/ha	6.0	18.6	41.9	30.4
4.+Amistar 0.5 l/ha	34.2	48.0	44.6	**66.2**
5.+Ensign 0.7 l/ha	6.9	27.7	33.6	40.0
6.+Ensign 0.35 l/ha	30.6	23.7	46.3	45.8

At this site the untreated control shows progressively worse margins as applied N is increased, reflecting the higher disease levels associated with increased nitrogen. (This was also evident at the highest N dose at the Andover site). The other figures show similar trends to the Andover results, with better margins as N dose is increased, but the half-rate strobilurins being more profitable than their full rate equivalents. Again, the half rate Amistar programme (4) at the highest nitrogen dose was the most cost-effective, but with the full rate, and both Ensign treatments, being less successful, the conventional programme (with 150 kg/ha N) was again the next most profitable treatment.

Table 18. **Cirencester - Net margins (2 year mean)**

Net margin £/ha

Applied nitrogen:	75kg N	100 kg	125 kg	150 kg
F programme:				
1.Untreated (c)	0.0(c)	-29.8	-11.2	-20.6
2.Opus + Corbel	30.9	30.2	39.9	39.0
3.+Amistar 1.0 l/ha	5.7	57.6	51.3	35.7
4.+Amistar 0.5 l/ha	73.5	78.9	79.3	**95.4**
5.+Ensign 0.7 l/ha	51.3	33.4	63.6	23.3
6.+Ensign 0.35 l/ha	76.2	46.5	73.3	61.3

Again the half rate Amistar programme was the most cost-effective, with N doses of 100 kg/ha or above. However the conventional programme, compared to data from other sites, was not consistently the ‘next best’ treatment, with the full rate Amistar treatment giving good returns at 100 and 125 kg/ha applied N.

Table 19. **Morley – Net margins (3 year mean)**

Net margin £/ha

Applied nitrogen:	75kg N	100 kg	125 kg	150 kg
F programme:				
1.Untreated (c)	0.0(c)	12.8	2.1	5.4
2.Opus + Corbel	29.8	50.0	46.1	73.9
3.+Amistar 1.0 l/ha	-10.2	23.0	26.7	53.1
4.+Amistar 0.5 l/ha	-2.2	41.2	65.5	**95.2**
5.+Ensign 0.7 l/ha	-28.8	13.0	44.4	69.3
6.+Ensign 0.35 l/ha	8.1	40.5	41.5	86.5

Here again the half rate Amistar programme was the most cost-effective, but this was only evident with 125 and 150 kg/ha applied N. Nevertheless this programme, with the highest N dose, was again the most cost-effective individual treatment in the trial. The conventional programme again compared well, particularly at the lower N doses.

Discussion

Throughout the trial series the spring barley crop gave yield responses to increased levels of applied N. The shape of this nitrogen response curve was generally similar for both conventional (triazole/morpholine), and strobilurin fungicide programmes. However the strobilurin programmes consistently gave higher yields than the conventional programme, (up to 1.7 t/ha higher) and so whilst the shape of the response curve was similar for both types of fungicides, the strobilurin curve was at a higher yield level.

In all but one trial, disease levels were held to a minimum (<5%) in all fungicide-treated plots, therefore these yield benefits from strobilurins were unlikely to be due to disease control differences.

Such differences in yield between the two fungicide types were more apparent at the higher levels of applied nitrogen, with the result that the highest yields consistently came from the highest N levels with strobilurin fungicides.

Of the strobilurin programmes themselves, the full rates of Amistar and Ensign, at both timings, generally gave higher yields than the half rates, though net margin analysis showed this was not always sufficient to make the full rates cost-effective. Amistar programmes gave higher yields than the Ensign programmes, though these effects were not consistent and not always statistically significant.
In some of the trials, strobilurin programmes also gave significantly higher specific weight than the conventional programme.

In terms of grain quality for malting, the figures indicate no increase in grain nitrogen associated with these strobilurin yield benefits. Where the grain N level at a site was high (e.g. Cirencester 1998, grain N above 2% with conventional fungicides) the extra yield from the strobilurins appeared to dilute this, bringing the levels down whilst still giving yield increases. In fact, the four-site mean figures for 1998 showed that using a half-rate Amistar (with Opus and Corbel) in each fungicide spray, and 150 kg/ha N produced a grain nitrogen figure of 1.64%. To achieve this grain N level with the conventional programme, applied N would have had to be restricted to 100 kg/ha, giving a yield penalty of 1.25 t/ha compared to the Amistar programme.

However in most cases the inherent grain nitrogen levels at a site were fairly low. In these cases there was less scope for this dilution of grain N and overall the strobilurin fungicides had little effect on it. In both cases, therefore, higher yields were achieved with strobilurins without raising grain nitrogen.

It also means that one of the original aims of the project, to combine low nitrogen doses with strobilurins for high yield with low grain N, was not successful since low N doses were not required for optimum low grain nitrogen, and so the yields and margins of these treatments simply reflected the low level of nitrogen applied.

Also, recent changes in the specifications for malting barley mean that excessively low grain nitrogen is also penalised. If strobilurins reduce grain N below an acceptable level, it could have the same effect on quality and profitability as high levels of applied nitrogen have traditionally had in pushing the grain N too high. This effect was seen in this project where strobilurin programmes were applied in conjunction with low levels of applied N (qv four site means for yield and grain N, 1998). This was offset by applying more nitrogen fertiliser, which in itself gives higher yield, with the result that the correct grain quality is achieved by increasing the yield, the complete opposite approach to that previously employed in malting barley agronomy.

Nevertheless it is important to highlight this potentially detrimental effect of strobilurins. If levels of applied N are not high enough, then reductions in grain N through higher yields could result in strobilurins compromising grain quality.

Similar effects were seen with specific weights and screenings. For both, the greatest influence came from fungicide treatment over no fungicide treatment. There were few differences between the fungicide treatments themselves, conventional or strobilurin. However, occasionally the strobilurin treatments did improve specific weight, and occasionally reduced screenings, more so than the conventional fungicides. It was therefore apparent that, as with grain nitrogen, strobilurin fungicides maintained or improved specific weight, and maintained or reduced screenings, compared to the conventional fungicides.

Throughout this project, however, the majority of grain samples showed grain N levels below the 1.6% minimum used in the net margin calculations, even with applied N levels of 150 kg/ha. In such cases there was no advantage in reducing applied N in order to achieve the necessary grain quality, and the yield penalties associated with low N applications meant that these were the least cost-effective. Net margins were frequently negative where nitrogen totals of 75 or 100 kg/ha were applied with strobilurins. (However such combinations may be appropriate where more extreme measures are needed to restrict grain nitrogen, for example where growers on heavy soils may be attempting to grow malting barley).

In such cases, with little chance of exceeding the maximum specified grain N, it was apparent that the highest doses of applied N were the most cost-effective, the extra yield associated with these more than compensating for the extra fertiliser cost. At these higher N levels particularly, strobilurin programmes were higher yielding than conventional, but the higher cost of the full rate strobilurins in each fungicide spray, meant that the conventional programme was, in many cases, more cost-effective than these. Also, with the yield advantages from Amistar frequently being higher than those with Ensign, the most cost-effective treatment at all four sites, averaged over the three years, was the half rate Amistar programme together with the highest N dose, 150 kg/ha.

As previously stated, over the course of the project, most grain samples produced were below 1.6%, even with 150 kg/ha applied nitrogen. In total, of 264 treatments (over four sites and three years), only 50 produced grain N in the required range thereby attracting a malt premium. Of the rest, the grain N was too high in only 15.

Nevertheless with those sites where the required grain N was achieved in some treatments, there is sufficient evidence to conclude that strobilurin fungicides can reduce grain nitrogen, bringing it to within acceptable levels where it would be otherwise too high. However if also coupled with low doses of applied nitrogen fertiliser, this reduction can be excessive, leaving the grain N too low.

Where the potential grain N at a site is low anyway, it would appear that, with less scope for further reduction, strobilurins have little, if any, effect on grain N.

In both cases there was a need to keep the level of applied nitrogen fairly high. Whilst the low grain nitrogen levels seen in the course of this project could be considered a seasonal effect, and Optic a variety with inherently low grain N, there are still clear dangers associated with the use of strobilurin fungicides in combination with low levels of applied nitrogen. Conversely, if nitrogen rates are raised where strobilurins are used, both inputs will give higher yields, and so the grower could possibly enjoy higher output from the spring barley crop whilst maintaining the grain quality required to attract a malt premium.

Strobilurin fungicides give superior disease control in spring barley over conventional chemistry, and for this reason most spring barley growers will be using them. Unless the field used is very fertile, (in which case it is unsuitable for malting barley production anyway) then whatever the likely 'background' grain nitrogen, fertiliser nitrogen doses will need to be higher than traditionally used. If it is likely to produce grain N levels around 2% or more, suggesting the need for little applied N, then more applied N will be needed since it is in these situations that the strobilurin effect is most likely to be seen, with grain nitrogen being diluted with the higher yield. If applied N is kept low, this may result in excessively low grain N. Conversely, where the fertility of the field is very low, the grower could possibly afford to maximise yield through strobilurins and high levels of applied N, and still achieve grain nitrogen levels in the required range.

In both cases, output of malt quality barley is likely to be higher than would have traditionally been expected.

This project has therefore given a valuable insight into the effects of strobilurin chemistry on malting spring barley production. Of the guidelines resulting from this, most are encouraging, pointing to increased output of good quality grain. There are also, however, dangers highlighted where certain combinations of inputs can compromise grain quality.

Appendix A

Individual site results for yield, specific weights, grain nitrogen, and screenings

(of those trials not featured in the main section)

1998
Caythorpe

1. Yields and specific weights

	Yields t/ha				Specific weight kg/hl			
Applied nitrogen:	**75kg N**	**100 kg**	**125 kg**	**150 kg**	**75 kg**	**100 kg**	**125 kg**	**150 kg**
F programme:								
1.Untreated (c)	4.73	5.25	5.16	5.01	70.5	71.0	70.3	70.6
2.Opus + Corbel	5.43	5.80	6.01	5.96	70.8	71.4	71.9	71.5
3.Amistar 1.0 l/ha	6.18	6.74	7.05	7.03	71.1	72.5	72.3	73.0
4.Amistar 0.5 l/ha	6.11	6.64	6.93	7.04	71.7	72.3	73.1	73.1
5.Ensign 0.7 l/ha	6.29	6.47	6.67	6.99	71.9	72.1	71.9	72.3
6.Ensign 0.35 l/ha	6.15	6.12	6.56	6.47	72.2	71.8	72.3	72.7

LSD (P=0.05) yield: 0.52. Specific weight:1.3

2. Grain nitrogen content and screenings

	% grain N				% screenings>2.5mm			
Applied nitrogen:	**75kg N**	**100 kg**	**125 kg**	**150 kg**	**75 kg**	**100 kg**	**125 kg**	**150 kg**
F programme:								
1.Untreated (c)	1.38	1.47	1.54	1.73	93.1	93.1	91.4	89.2
2.Opus + Corbel	1.24	1.50	1.31	1.64	94.3	94.8	94.0	94.2
3.Amistar 1.0 l/ha	1.34	1.45	1.42	1.58	94.6	94.5	95.1	95.5
4.Amistar 0.5 l/ha	1.32	1.55	1.52	1.69	95.1	95.8	95.6	95.4
5.Ensign 0.7 l/ha	1.49	1.69	1.41	1.48	95.2	95.0	94.7	94.7
6.Ensign 0.35 l/ha	1.35	1.44	1.46	1.54	95.6	94.5	94.6	95.1

LSD (P=0.05) grain N: 0.15. Screenings: 1.5

Morley

1. Yields and specific weights

	Yields t/ha				Specific weight kg/hl			
Applied nitrogen:	**75kg N**	**100 kg**	**125 kg**	**150 kg**	**75 kg**	**100 kg**	**125 kg**	**150 kg**
F programme:								
1.Untreated (c)	5.22	5.48	5.53	5.78	70.0	69.6	69.3	69.2
2.Opus + Corbel	6.24	6.74	6.73	7.12	71.2	71.0	71.5	71.4
3.Amistar 1.0 l/ha	6.78	7.64	7.52	7.83	70.9	71.3	71.7	72.0
4.Amistar 0.5 l/ha	6.69	7.05	7.73	7.70	71.1	71.9	71.7	72.1
5.Ensign 0.7 l/ha	6.43	7.02	7.70	7.49	70.9	71.4	71.2	71.3
6.Ensign 0.35 l/ha	6.21	7.03	7.21	7.66	71.1	71.5	72.2	71.6

LSD (P=0.05) yield: 0.81. Specific weight: 0.8

2. Grain nitrogen content and screenings

	% grain N				% screenings>2.5mm			
Applied nitrogen:	**75kg N**	**100 kg**	**125 kg**	**150 kg**	**75 kg**	**100 kg**	**125 kg**	**150 kg**
F programme:								
1.Untreated (c)	1.56	1.64	1.70	1.80	95.6	94.7	93.2	92.4
2.Opus + Corbel	1.61	1.53	1.61	1.70	97.2	96.9	96.3	95.3
3.Amistar 1.0 l/ha	1.52	1.58	1.62	1.69	97.5	97.1	96.3	96.1
4.Amistar 0.5 l/ha	1.40	1.53	1.62	1.66	96.4	97.6	96.9	97.1
5.Ensign 0.7 l/ha	1.44	1.52	1.64	1.80	97.7	97.4	96.0	95.4
6.Ensign 0.35 l/ha	1.44	1.53	1.69	1.70	97.6	96.9	96.8	95.9

LSD (P=0.05) grain N: 0.1. Screenings: 2.4

1999

Caythorpe

1. Yields and specific weights

	Yields t/ha				Specific weight kg/hl			
Applied nitrogen:	**75kg N**	**100 kg**	**125 kg**	**150 kg**	**75 kg**	**100 kg**	**125 kg**	**150 kg**
F programme:								
1.Untreated (c)	4.89	4.96	5.27	5.22	68.3	68.2	68.5	68.1
2.Opus + Corbel	5.83	6.2	6.44	6.73	70.2	70.1	70.2	70.5
3.Amistar 1.0 l/ha	6.24	6.72	7.2	7.34	71	71.6	71.1	71.5
4.Amistar 0.5 l/ha	6.24	6.8	6.84	7.37	70.9	70.7	71.1	71.6
5.Ensign 0.7 l/ha	6.16	6.59	7.07	7.49	70.4	71.7	70.7	71.1
6.Ensign 0.35 l/ha	6.17	6.21	6.79	7.15	70.1	70.3	70.5	70.2

LSD (P=0.05) yield: 0.4. Specific weight: 1.1

2. Grain nitrogen content and screenings

	% grain N				% screenings >2.5mm			
Applied nitrogen:	75kg N	100 kg	125 kg	150 kg	75 kg	100 kg	125 kg	150 kg
F programme:								
1.Untreated (c)	1.36	1.44	1.46	1.55	90.7	89.5	88.7	87.5
2.Opus + Corbel	1.26	1.36	1.4	1.46	95.6	94.2	93.9	94.5
3.Amistar 1.0 l/ha	1.32	1.38	1.38	1.5	94.8	95.8	96.1	94.7
4.Amistar 0.5 l/ha	1.32	1.4	1.45	1.45	95.9	95.9	94.6	95.1
5.Ensign 0.7 l/ha	1.3	1.34	1.37	1.47	94.9	95.0	95.7	94.2
6.Ensign 0.35 l/ha	1.3	1.31	1.41	1.46	95.1	94.1	94.5	94.5

LSD (P=0.05) grain N: 0.13. Screenings: 0.4

Cirencester

1. Yields and specific weights

	Yields t/ha				Specific weight kg/hl			
Applied nitrogen:	75kg N	100 kg	125 kg	150 kg	75 kg	100 kg	125 kg	150 kg
F programme:								
1.Untreated (c)	5.83	5.78	5.87	5.81	70.7	71.1	68.8	67.6
2.Opus + Corbel	6.52	6.93	7.1	7.42	72.7	72.4	72.9	72.6
3.Amistar 1.0 l/ha	6.62	7.34	7.76	8.11	72.8	73.4	72.9	73.6
4.Amistar 0.5 l/ha	7.05	7.39	7.82	8.05	72.7	73.7	72.4	72.8
5.Ensign 0.7 l/ha	7.07	7.48	7.79	7.65	72.9	72.6	73.1	71.7
6.Ensign 0.35 l/ha	7.02	7.27	7.69	7.7	72.6	73	73	73.1

LSD (P=0.05) yield: 0.59. Specific weight: 0.6

2. Grain nitrogen content and screenings

	% grain N				% screenings >2.5mm			
Applied nitrogen:	75kg N	100 kg	125 kg	150 kg	75 kg	100 kg	125 kg	150 kg
F programme:								
1.Untreated (c)	1.33	1.41	1.55	1.68	92.0	90.8	83.8	77.7
2.Opus + Corbel	1.34	1.41	1.48	1.55	94.4	95.2	95.0	93.6
3.Amistar 1.0 l/ha	1.36	1.38	1.46	1.57	96.9	96.9	95.7	95.3
4.Amistar 0.5 l/ha	1.33	1.41	1.53	1.61	96.1	97.1	96.0	96.1
5.Ensign 0.7 l/ha	1.33	1.38	1.44	1.58	95.9	95.3	95.7	94.7
6.Ensign 0.35 l/ha	1.38	1.37	1.59	1.61	96.2	95.7	95.7	94.2

LSD (P=0.05) grain N: 0.13. Screenings: 2.2

2000

Caythorpe

1. Yields and specific weights

	Yields t/ha				**Specific weight kg/hl**			
Applied nitrogen:	**75kg N**	**100 kg**	**125 kg**	**150 kg**	**75 kg**	**100 kg**	**125 kg**	**150 kg**
F programme:								
1.Untreated (c)	5.59	5.62	5.58	5.71	66.3	66.3	65.3	65.1
2.Opus + Corbel	6.34	6.61	6.64	6.84	67.5	67.7	67.9	67.4
3.Amistar 1.0 l/ha	7.23	7.29	7.60	7.42	69.2	68.9	69.2	68.1
4.Amistar 0.5 l/ha	6.87	7.28	7.25	7.13	67.9	68.5	68.5	67.9
5.Ensign 0.7 l/ha	6.84	7.13	7.24	7.28	68.7	68.6	68.6	68.6
6.Ensign 0.35 l/ha	6.79	6.90	7.08	7.22	68.3	67.9	68.0	68.2

LSD (P=0.05) yield: 0.41. Specific weight: 1.2

2. Grain nitrogen content and screenings

	% grain N				**% screenings >2.5mm**			
Applied nitrogen:	**75kg N**	**100 kg**	**125 kg**	**150 kg**	**75 kg**	**100 kg**	**125 kg**	**150 kg**
F programme:								
1.Untreated (c)	1.57	1.63	1.72	1.84	94.4	94.4	93.1	91.2
2.Opus + Corbel	1.68	1.55	1.65	1.73	95.7	95.9	95.3	95.3
3.Amistar 1.0 l/ha	1.53	1.59	1.69	1.83	96.1	96.7	96.7	96.5
4.Amistar 0.5 l/ha	1.61	1.56	1.54	1.71	95.6	95.6	96.2	96.4
5.Ensign 0.7 l/ha	1.49	1.58	1.64	1.69	96.6	95.9	95.8	96.2
6.Ensign 0.35 l/ha	1.53	1.57	1.64	1.70	96.1	96.1	95.9	95.9

LSD (P=0.05) grain N: 0.1. Screenings: 1.6

Appendix B

Values used for net margin analysis

Grain price (feed)	£60/tonne
Grain price (malt)	£76/tonne
Fertiliser costs:	
Nitrogen	£0.377 /kg N
Fungicide costs:	
Opus	£22/ litre
Corbel	£21/ litre
Amistar	£30/ litre
Ensign	£35/litre

References

Arable Research Centres (1997). Spring barley disease control. *Agronomy #6,* May 1997 (restricted circulation)

Institute of Brewing (1999). New attitudes to new varieties. *Malting Barley News,* Summer 1999

MAFF, (1994). *Fertiliser Recommendations for Agricultural and Horticultural Crops* (RB209) - 6th edition. Ministry of Agriculture, Fisheries and Food. Her Majesty's Stationery Office, London.

HGCA (2001) Introductory guide to Malting Barley. *HGCA publications.*

Acknowledgements

The author acknowledges the funding provided for the project by the HGCA.

Also the information provided by the Maltsters Association of Great Britain, in particular R.King and M.Gutsell, with reference to grain prices relative to malt quality criteria.

ANNEX TO
PROJECT REPORT No. 250

This document forms an Annex to Project Report No. 250 and reports the findings of a one-year extension project which started in January 2001. The work was funded by a grant of £24,688 from HGCA (project 1566).

Abstract

As in the earlier Project Report (No. 250), the influence of strobilurin fungicide programmes on the response to increasing levels of nitrogen fertiliser was evaluated, in terms of yield and grain quality for malt production. Trials were conducted at four locations over three years. In this project, two additional cultivars were added, (Decanter and Chariot), in order to see whether the effects on grain nitrogen from strobilurin fungicides seen earlier in Optic would also be seen in other varieties.

Fungicide treatments were reduced to three: an untreated control, a conventional (non-strobilurin) programme, and a strobilurin-based programme involving the product Amistar (azoxystrobin). The number of nitrogen doses applied remained at four (75, 100, 125, 150 kg/ha).

Disease levels in spring barley in 2001 were very low, with no significant infections being recorded at any site. However, at the Morley site, there were notable benefits in retention of green leaf area (GLA) resulting from the strobilurin programme, for all varieties.
Yield responses to fungicide treatment were small, again for all varieties, though the strobilurin programme tended to outyield the conventional programme, which in turn outyielded the untreated control, in the majority of cases. However, in nearly all comparisons, the strobilurin programme was the least cost-effective.

Screenings and specific weights also showed little differences between fungicide treatments.
The lack of yield responses to strobilurins meant that any influence on grain quality was difficult to detect. The reduction in grain nitrogen, seen frequently in the earlier project, was seen at two of the sites in Optic, with no such effect seen in either Chariot or Decanter.

Nevertheless the degree of grain N reduction was small compared to earlier results, and not sufficient to allow valid variety comparisons.

Despite the lack of 'strobilurin effect' in this one-year project, there was still a tendency, also seen consistently in the earlier work, for high levels of applied N to be necessary to achieve sufficiently high grain N levels for the typical market requirements (1.60-1.85%N). Irrespective of fungicide treatment, most grain samples produced from N applications of 75 or 100 kg/ha were below 1.60% grain N. Even at 150 kg/ha, one third of samples produced were below 1.60%, with only one quarter above 1.85%.

The widespread use of strobilurin fungicides in spring malting barley will mean that growers will need to readjust their traditional fertiliser-N doses to allow for any grain N 'dilution'. Whilst this effect was not seen in 2001 as clearly as in the earlier work, there was still a tendency for grain N levels to be too low when traditional fertiliser-N doses were applied, even without the yield benefits associated with strobilurins.
It was not possible in this project to conclusively identify a varietal effect in response of grain quality to strobilurin fungicides.

Summary – extension project

Introduction

The work outlined in this annex report was a one-year extension to an earlier project (HGCA 1566, Project Report number 250) which examined the influence of strobilurin fungicides on grain quality in malt spring barley, in particular their interaction with the amount of nitrogen fertiliser used.
The superior disease control given by strobilurins was found to raise the yield level of the crop to the extent that the grain N appeared to be 'diluted', frequently to levels below those required by the export malt barley market. As a result the levels of nitrogen fertiliser applied needed to be raised in order to maintain the correct quality.

The readiness with which the grain nitrogen levels were diluted by the extra yield achieved through the use of strobilurin fungicides, led some to suggest that the variety used in the project (Optic) was having an influence. Optic is thought by many to be a 'low grain N variety', such that grain nitrogen levels might be more readily manipulated than in other cultivars. To investigate this an extension to the original project was set up to look at some of the experimental treatments on more than one variety. If the husbandry guidelines resulting from the original project could also be shown to be relevant to other varieties, then these guidelines would be applicable to a higher proportion of the UK spring barley crop.
The work carried out in the original project was therefore continued in the 2001 season on three spring barley cultivars, with slightly fewer treatments, at the same trial locations.

In summary, the objectives of the extension project were to:

- measure the yield response in spring barley to strobilurin fungicides, over that achieved with 'conventional' (triazole/morpholine) fungicides.
- assess what extra yield could be achieved with strobilurins and as a result what level of fertiliser nitrogen is required to achieve a desirable grain nitrogen level.
- compare these responses in three spring barley cultivars.
- assess the cost-effectiveness of the strobilurin fungicide programmes in relation to their effects on grain quality.

Materials and methods

Field trials

In the spring of 2001, field trials were sown at each of four locations in England, all in areas associated with malting barley production. These were:

Trial site	**Soil type**
Caythorpe, nr. Grantham, Lincs	-343a Elmton (brashy calcareous loam over limestone)
Morley, nr. Wymondham, Norfolk	-572q Ashley (sandy loam over chalky boulder clay)
Andover, Hampshire	-343h Andover (shallow calcareous soil over chalk)
Cirencester, Gloucestershire	-343a Elmton (brashy calcareous loam over limestone)

All trials were sown between early February and mid-April, at a seed rate appropriate to the area (between 350 and 450 seeds/m^2).

Experimental treatments

The trials involved a total of 12 treatments, applied to each of three varieties: Optic, Chariot, and Decanter.

Individual treatments involved a combination of nitrogen fertiliser quantity and fungicide programme. The four nitrogen levels were 75, 100, 125, and 150 kg/ha N, all applied as a single dose soon after emergence. Three two-spray fungicide programmes were applied to each N level, as follows:

7. Untreated control
8. Opus 0.25 l/ha + Corbel 0.28 l/ha
9. As 2, plus Amistar 0.5 l/ha.

All fungicide treatments applied twice, at GS 30 and GS 45-49.

Opus contains epoxiconazole (125 g/l). Corbel contains fenpropimorph (750 g/l). Amistar contains azoxystrobin (250 g/l).

The treatment combinations therefore give a nitrogen response curve, from 75 to 150 kg/ha, for each of the three disease control programmes.

Assessments

For each trial, assessments were made of the following:

- Disease observations at the end of the season
- Grain yield
- Specific weight

- Grain nitrogen content
- Screenings (% grain retained over a 2.5mm sieve)

Results

The following section outlines the yield, grain quality, green leaf areas (GLA) and net margins (i.e. margins over input cost).

Note that for the yields and grain quality data, the four-site mean results are presented here. Individual site results can be found in the Appendix.

Cost-benefit analysis:

The cost-benefit calculations in this report make the following assumptions on grain price relative to grain quality, following discussions with the Maltsters Association of Great Britain:

Below 1.6%, or above 1.85% - feed price only.

This is taken as a typical feed barley price at harvest 2001, i.e. £60/tonne.

Grain nitrogen 1.6-1.85% - feed barley price plus malting premium.

The malt premium used here is taken as £16/tonne, (though this would vary slightly with market fluctuations).

Whilst it is accepted that there are still markets for low grain nitrogen samples below 1.6%, these are now a small percentage of the market, particularly for growers in England. There is still a significant distilling market in Scotland, which requires low grain nitrogen, nevertheless approximately 60% of the UK market now specifies samples in the range 1.6-1.85%. In most cases it is likely that samples outside this range, above or below it, will be unacceptable as malting barley and will therefore be sold as feed barley.

Therefore, whilst not applicable to the whole UK market, it is felt that these assumptions, and therefore the conclusions based on them, are relevant to a large proportion of UK growers.

1. Disease levels and Green Leaf Areas (GLA)

Disease levels on the untreated controls at all four sites were very low, and although the fungicide programmes controlled the disease, the differences were inconsistent and the exceptionally low disease pressure, a general feature of the 2001 season, invalidated any disease control comparisons.

The disease levels, of the most prominent diseases, recorded at each site can be summarised as follows:

Andover: levels of *Rhynchosporium secalis* reached 10% (of whole plant) in untreated plots of Chariot at 150 kg/ha N. Levels on untreated plots with less N were around 5%, but all fungicide treatments reduced disease levels to less than 2%.

Caythorpe: levels of disease in all plots were below 2%.

Morley: Mildew on leaf 2 of Chariot reached 4% in some plots, but levels in the majority of plots were less than 1%.

Cirencester: Untreated plots of Optic, at the higher N levels, reached 6% *R . secalis,* but all other treatments, on other varieties, showed levels at less than 2%.

However there were noticeable differences in green leaf retention at the end of the season, particularly at the Morley site. The following figures outline the GLA values for the range of nitrogen/fungicide treatments.

Green leaf area, leaf 2, 1st August (% leaf area) – (Morley)

Applied N:	**75 kg/ha**	**100**	**125**	**150**
Variety/F programme				
Optic				
Untreated	3.7	17.3	29.3	28.3
Conventional	33.0	31.3	68.3	70.0
Strobilurin	36.7	44.0	65.0	75.0
Chariot				
Untreated	0	0	0.3	1.0
Conventional	2.3	4.7	9.7	21.7
Strobilurin	2.0	13.7	19.7	39.0
Decanter				
Untreated	3.0	1.7	7.0	3.0
Conventional	17.7	30.7	46.7	64.3
Strobilurin	15.0	25.3	68.3	69.0
Mean	**12.6**	**18.7**	**34.9**	**41.3**

LSD 6.0

Despite a lack of disease, the fungicide programmes had a marked effect on the preservation of GLA. With Optic and Decanter there were no consistent benefits from either the strobilurin or conventional programme, but with Chariot the strobilurin programme gave significantly higher values than the conventional programme at three of the applied N levels.

The fungicide-untreated plots showed a slightly lower GLA from 150 kg/ha than from 125 kg/ha, at which level the GLA figures, although very low in the untreated, appeared to peak. However, where fungicides were applied, either strobilurin or conventional, the highest N doses gave the best GLA values for all varieties.

2. Yields and grain quality (four-site means)

a) Yield (t/ha) and specific weight (kg/hl)

	Yield (t/ha)					Specific wt (kg/hl)			
Applied N:	**75 kg/ha**	**100**	**125**	**150**		**75 kg/ha**	**100**	**125**	**150**
Variety/F programme									
Optic									
Untreated	4.39	4.82	5.05	5.70		65.5	65.3	65.5	65.6
Conventional	4.54	5.19	5.51	5.86		65.2	65.8	66.0	66.6
Strobilurin	4.80	5.46	5.75	6.08		65.3	66.0	66.2	66.3
Chariot									
Untreated	4.32	4.69	4.95	5.31		65.4	66.2	66.1	66.3
Conventional	4.34	4.82	5.24	5.51		66.1	66.4	66.7	67.0
Strobilurin	4.63	5.09	5.41	5.67		65.7	66.1	67.0	66.6
Decanter									
Untreated	4.18	4.77	5.08	5.49		65.7	65.8	66.2	65.8
Conventional	4.33	5.08	5.46	5.83		65.4	66.3	65.6	66.4
Strobilurin	4.60	5.13	5.55	5.98		65.4	66.2	66.2	66.4

In all cases the fungicide programmes outyielded the untreated control, and the strobilurin programmes outyielded the conventional (triazole/morpholine) programmes. The latter point was also true at each of the individual sites, however at the lower levels of applied nitrogen, the conventional programme did not always outyield the untreated control for the varieties Chariot and Decanter.

Generally the responses to the fungicide programmes were considerably less than were seen in the previous three years' trials, a reflection of the lack of disease in each of the four trials. In previous years, responses to strobilurin programmes over conventional programmes have been over 1 t/ha, whereas in this 2001 trial series with Optic the same comparison rarely showed a benefit to strobilurins above 0.3t/ha.

Specific weights: there was a slight tendency for specific weight to improve as the amount of applied nitrogen is increased, but these increments were very small. There were no differences in specific weight between the three fungicide treatments, nor between the three varieties.

b) Grain nitrogen (%) and screenings > 2.5mm

	% grain nitrogen					% screenings > 2.5mm			
Applied N:	**75 kg/ha**	**100**	**125**	**150**		**75 kg/ha**	**100**	**125**	**150**
Variety/F programme									
Optic									
Untreated	1.49	1.48	1.56	1.67		95.1	95.3	95.8	96.4
Conventional	1.50	1.53	1.60	1.71		96.0	96.1	97.1	95.8
Strob	1.47	1.54	1.58	1.65		96.1	96.5	96.6	97.0
Chariot									
Untreated	1.51	1.55	1.70	1.80		95.7	96.4	96.0	96.3
Conventional	1.52	1.57	1.69	1.80		96.5	96.4	96.5	96.2
Strob	1.53	1.58	1.70	1.80		96.6	96.5	96.6	96.3
Decanter									
Untreated	1.46	1.52	1.59	1.65		94.9	93.9	94.0	93.7
Conventional	1.52	1.57	1.61	1.71		96.0	95.7	94.7	95.1
Strobilurin	1.48	1.52	1.67	1.72		96.3	95.9	95.6	95.9

Comparing the conventional (triazole-based) fungicide programme with the strobilurin programme, there were no consistent effects on grain nitrogen content. This contrasts with earlier results where the strobilurin programmes appeared to reduce grain N compared to the conventional programme. However this was assumed to be a dilution effect from the higher yields achieved with strobilurins. Since such yield responses were not seen in 2001, this might explain the absence of any noticeable effects on grain nitrogen. (Figures 1 & 2)

At Cirencester, however, there was an apparent reduction in grain N with Optic, when the strobilurin and conventional programmes were compared, at the higher applied N levels:

		% grain N		
Applied nitrogen:	75 kg/ha N	100kg/ha	125 kg/ha	150 kg/ha
Fungicide programme:				
Conventional	1.46	1.47	1.57	1.71
Strobilurin	1.41	1.46	1.47	1.57

This was associated, to some extent, with higher yields from the strobilurin programme:

	Yield (t/ha)			
Applied nitrogen:	75 kg/ha N	100kg/ha	125 kg/ha	150 kg/ha
Fungicide programme:				
Conventional	4.47	5.08	4.98	5.62
Strobilurin	4.71	5.32	5.37	5.78

(See figure 3)

Similar effects were seen at the Caythorpe site, though the differences were smaller.
This effect is typical of those seen in the earlier project on this variety. The same effect was not seen at either site, in either Chariot (Figure 4) or Decanter, thus indicating a differential variety response. However no such effects were seen in any of the three varieties at the other two sites, and what differences there were at Caythorpe and Cirencester were smaller than had been recorded in previous years.

The four-site mean figures above suggest that none of the treatments receiving 75 or 100 kg/ha nitrogen produced a grain N level high enough to qualify as a malt sample, i.e. were below 1.6%. This underlines the need for total N doses on spring malt barley crops to be higher than traditional levels, with the current market requirements (unless the crop is grown for a specialised low-N end use).
The individual site figures for grain N (see Appendix) indicate the proportion of samples in each nitrogen programme which would qualify as malt quality, assuming parameters of 1.6-1.85%. For each nitrogen treatment, there were 36 site/fungicide/variety combinations, thereby giving 36 samples for each N level.

The following table gives the number of samples of the 36 which did not fall within these parameters, and of this number, the number for which the grain N was too high and too low respectively.

Applied N (kg/ha)	No. samples outside 1.6-1.85% grain N	No.< 1.6%	No. >1.85%
75	30	30	0
100	23	23	0
125	16	13	3
150	21	12	9

Where the level of applied N was restricted to 75 kg/ha, 30 out of 36 samples recorded grain N levels below what would be suitable for the majority of the current market. This was irrespective of fungicide programme. None of the samples in this group were too high in grain N.

As the applied N level was increased, fewer samples had excessively low grain N, and more had grain N above 1.85%. Overall the optimum N level appeared to be 125 kg/ha, with 20 of the 36 samples recording grain N in the 1.6-1.85% bracket, though over a third (13) still recorded grain N levels below 1.6%. At 150 kg/ha N, only 15 samples gave the 'optimum' grain N, with 9 (25%) recording values that were excessively high.

Generally the above data still suggests that traditional malt barley nitrogen programmes of 75 or 100 kg/ha are now too low for the majority of the market. The earlier project indicated that 150 kg/ha (or higher) was the optimum for the target grain nitrogen. In this series of trials the optimum appears to be 125 or 150 kg/ha.

It is worth noting, however, that of the four sites, Morley tended to produce fewer samples with low grain N, and relatively more of the 75 kg/ha samples were in the 1.6-1.85% range. This was also the site that was drilled latest (11th April). Later-sown crops tend to produce higher grain nitrogen than earlier sowings. In this case the lower applied N levels would have been more appropriate to such later sowings.

The figures for screenings show a slight improvement across all three varieties resulting from fungicide treatment, but no clear differences between the two types of fungicide programme. This was true of all four datasets, with no clear benefits in screenings from strobilurin fungicides recorded in any of the trials.

Fig. 1: Influence of strobilurin fungicides on nitrogen response-yield

4 site mean 2001-**Optic**

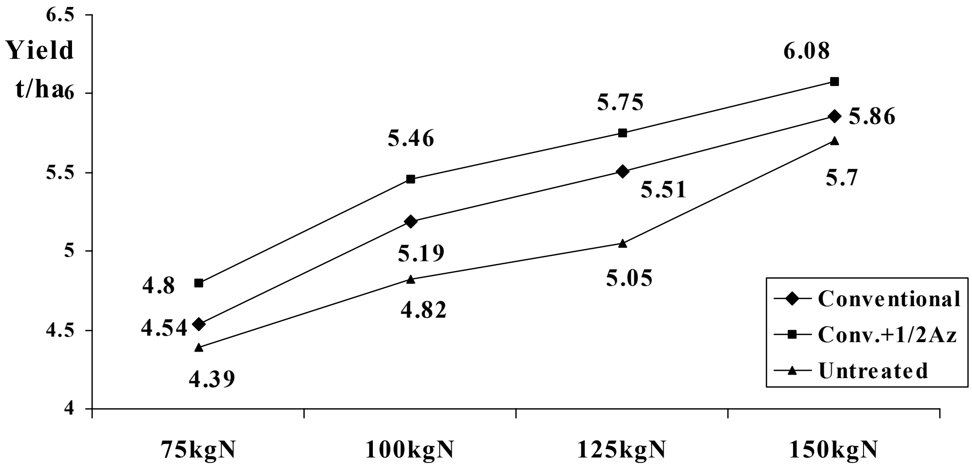


Fig. 2: Influence of strobilurin fungicides on nitrogen response-grain nitrogen

4 site mean 2001-**Optic**

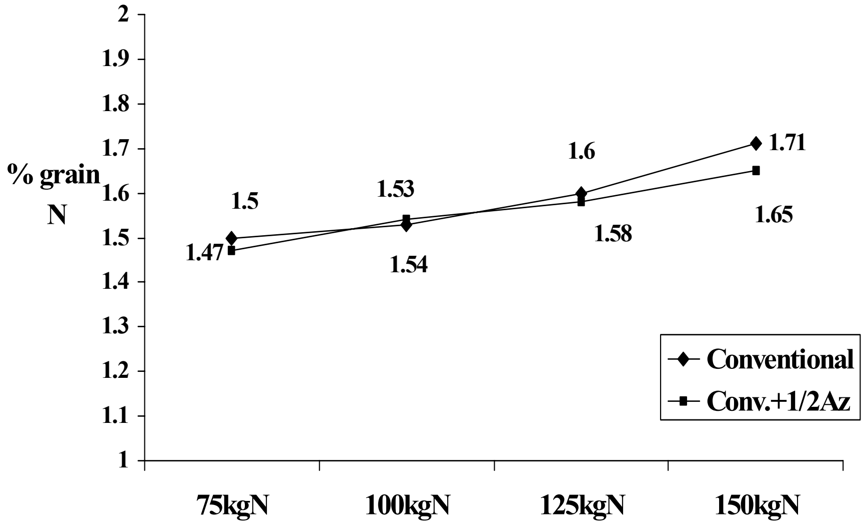


Fig. 3: Influence of strobilurin fungicides on nitrogen response-grain N

Cirencester 2001-**Optic**

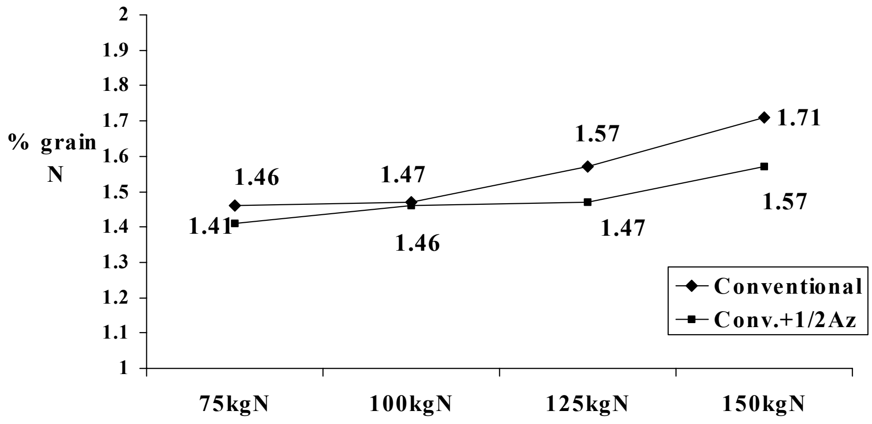
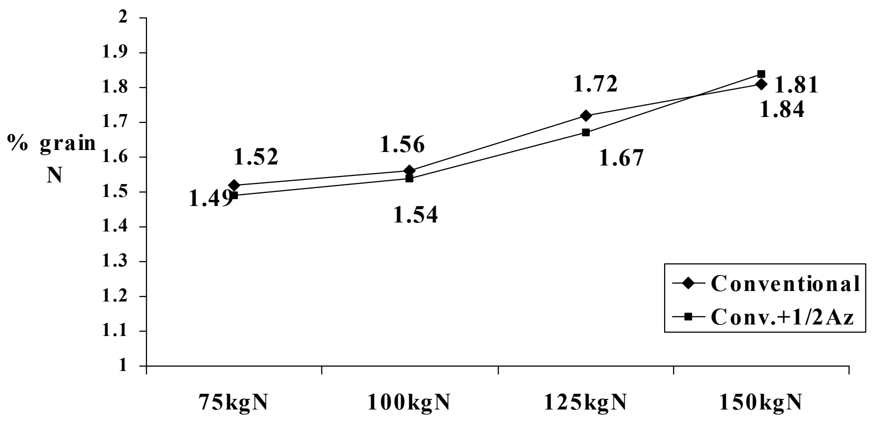


Fig. 4: Influence of strobilurin fungicides on nitrogen response-grain N

Cirencester 2001-**Chariot**



Cost-benefit analysis

The following tables give the net margins achieved by the fungicide and nitrogen combinations. For these calculations, the untreated fungicide control, with the lowest N fertiliser level (75 kg/ha) are taken as a zero control. The margins calculated then represent the profit/loss achieved for each increase in input above this point, for each of the four trial sites. A four-site mean is also presented.

Net margins (£/ha)

	Andover					Caythorpe			
Applied N:	**75 kg/ha**	**100**	**125**	**150**		**75 kg/ha**	**100**	**125**	**150**
Variety/F programme									
Optic									
Untreated	0	36	62	93		0	12	-1	42
Conventional	-19	12	47	73		-18	8	43	37
Strobilurin	-48	1	30	32		-17	20	14	23
Chariot									
Untreated	0	25	45	56		0	13	1	30
Conventional	-27	-6	20	43		-33	14	29	33
Strobilurin	-48	-14	2	14		-24	12	14	14
Decanter									
Untreated	0	44	77	97		0	38	32	63
Conventional	-27	25	56	81		-7	29	70	46
Strobilurin	-34	5	34	63		-26	9	33	14

	Morley					Cirencester			
Applied N:	**75 kg/ha**	**100**	**125**	**150**		**75 kg/ha**	**100**	**125**	**150**
Variety/F programme									
Optic									
Untreated	0	18	33	46		0	8	4	54
Conventional	10	55	43	38		-34	17	20	26
Strobilurin	-6	30	26	44		-51	-22	-28	-12
Chariot									
Untreated	0	2	21	-6		0	12	37	68
Conventional	-28	2	2	-10		-11	-12	39	45
Strobilurin	-45	-23	-22	-36		-37	-32	15	35
Decanter									
Untreated	0	-2	14	18		0	27	53	57
Conventional	-31	30	21	51		-4	19	42	74
Strobilurin	-39	10	-17	0		-31	-32	18	16

Net margins - four-site mean (£/ha)

Applied N:	**75 kg/ha**	**100**	**125**	**150**
Variety/F programme				
Optic				
Untreated	0	19	25	59
Conventional	-15	23	38	44
Strobilurin	-31	7	11	22
Chariot				
Untreated	0	13	26	37
Conventional	-25	-1	23	28
Strobilurin	-39	-14	2	7
Decanter				
Untreated	0	27	44	59
Conventional	-17	26	47	63
Strobilurin	-33	-2	17	23

Disease levels were low across all N treatments, but it is clear from these figures that applying any fungicides when the N fertiliser level was low (75 kg/ha) was not cost-effective. Both fungicide programmes produced a net loss in all varieties when used in conjunction with 75 kg/ha applied nitrogen. Individual site figures show that there was only one exception to this, at Morley with Optic, with 75 kg/ha N, where the conventional fungicide programme generated a relative profit of £10/ha.

The margins improved as the nitrogen was increased, and for Optic and Chariot the most profitable treatment was the highest N dose (150 kg/ha) with no fungicide treatment. For Decanter this treatment, and the same N with a conventional fungicide programme, gave similar margins, which were optimum for that variety.

Of the 36 variety/nitrogen combinations, only one (Caythorpe, 100 kg/ha N) showed the strobilurin programme to be the most cost-effective. In all other comparisons the most cost-effective was either the conventional programme, or no fungicides at all.

Discussion

The yields of all three varieties of spring barley were increased by increased levels of applied nitrogen. They were also increased by fungicide treatment, the increases from strobilurin fungicides being generally higher than those from conventional (triazole/morpholine) treatments. However, due to very low disease levels, these yield increases were considerably less than has been recorded previously in similar trials, and corresponding effects on grain quality were not as clear as in previous trials. There was an indication of a reduction in grain nitrogen corresponding to an increase in grain yield from the strobilurin programme, at Cirencester and Caythorpe, but these effects were fairly small compared to those seen previously.

One potential drawback of grain N reduction through strobilurin use, noted in the early work, is the possibility of the grain N being reduced to a level below that required for the majority of the malting barley market. Whilst the strobilurin effect on grain N was not as apparent here, it was noted that all grain N levels, irrespective of fungicide treatment, were fairly low and there may therefore be a general need to apply higher fertiliser nitrogen doses to compensate, irrespective of the disease control programme employed.

With Optic and Decanter, grain samples achieved 1.65% grain N fairly consistently with applied N doses of 150 kg/ha (the highest level tested). The samples from Chariot showed that this level could be achieved with 125 kg/ha N, though 150 kg/ha was not excessive. Again there was no consistent effect of fungicide programme on this.

The exceptions to these minimum applied N doses were seen at the Morley site, which was sown late and as a result the applied nitrogen had to be restricted to lower totals to maintain malting grain quality. In most cases 150 kg/ha applied N was excessive in this respect.

It should also be pointed out that the soil types at the four sites in this project can be described as light. On heavier soils the amount of fertiliser N would probably need to be lower than the optima described here, but since heavy soils tend to be less successful at growing malt quality spring barley, the principle of higher N totals being required could still apply, albeit at a different level.

Screenings were not significantly influenced by fungicide programme or N total, though Decanter produced slightly higher levels than either Optic or Chariot. In all three varieties specific weights were improved slightly by fungicide treatment, with no consistent difference between the conventional and strobilurin programmes in this respect.

It is therefore difficult to relate the results of this extension project to those of the earlier work, due to the lack of strobilurin effect on grain quality. In fact the lack of disease in 2001 led to the untreated control being the most cost-effective in most cases. Where it wasn't (most frequently in Decanter) the conventional fungicide programme still gave a higher margin than the strobilurin programme. In fact the strobilurin programme was most cost-effective in only one of the 48 site/N/cultivar comparisons.

Nevertheless, it was still clear that grain nitrogen levels were too low for market specifications unless applied nitrogen levels were higher than would have traditionally been used for spring malting barley. This was true in the main project, and in this extension work also. When disease levels are such that the use of strobilurin fungicides produces significant yield responses, these responses have resulted in a reduction in grain nitrogen below that required for the majority of the market. As a result the applied N dose has needed to be increased. However, even where grain N levels are not significantly influenced by fungicide treatment, they still tend to be too low with the lower nitrogen doses. There is therefore a need to adjust the levels of N applied to spring malting barley. Although strobilurin fungicides may not always reduce grain N levels, they appear to have the potential to do so. Their widespread use in the crop suggests that, with the current market requirements, growers should allow for such an effect and keep the level of applied N sufficiently high to counteract any such effects should they occur.

Appendix 1. Individual site results

The yields and grain quality data for the individual trial sites are given here.

1. Andover

a) Yields and specific weights

	Yield (t/ha)					Specific weight (kg/hl)			
Applied N:	**75 kg/ha**	**100**	**125**	**150**		**75 kg/ha**	**100**	**125**	**150**
Variety/F programme									
Optic									
Untreated	4.09	4.84	5.43	6.11		63.8	64.3	64.6	64.2
Conventional	4.20	4.88	5.61	6.20		64.6	64.3	65.3	65.3
Strobilurin	4.25	5.22	5.86	6.05		63.8	64.5	65.1	64.0
Chariot									
Untreated	3.94	4.51	4.99	5.34		64.6	65.4	65.4	64.2
Conventional	3.92	4.43	5.01	5.55		66.4	65.9	66.4	65.0
Strobilurin	4.10	4.83	5.24	5.61		65.3	64.6	66.4	64.6
Decanter									
Untreated	3.54	4.43	5.12	5.62		65.8	65.4	65.1	66.5
Conventional	3.53	4.54	5.20	5.79		64.8	66.5	64.7	65.6
Strobilurin	3.94	4.74	5.38	6.02		64.1	65.3	65.6	65.9

b) Grain nitrogen (%) and screenings > 2.5mm

	% grain nitrogen					% screenings >2.5mm			
Applied N:	**75 kg/ha**	**100**	**125**	**150**		**75 kg/ha**	**100**	**125**	**150**
Variety/F programme									
Optic									
Untreated	63.8	64.3	64.6	64.2		90.1	91.6	93.6	95.5
Conventional	64.6	64.3	65.3	65.3		93.6	93.5	95.7	96.1
Strob	63.8	64.5	65.1	64.0		92.4	93.8	95.2	95.8
Chariot									
Untreated	64.6	65.4	65.4	64.2		93.8	96.0	95.6	95.5
Conventional	66.4	65.9	66.4	65.0		95.0	95.8	95.3	96.1
Strob	65.3	64.6	66.4	64.6		94.2	95.4	95.8	95.7
Decanter									
Untreated	65.8	65.4	65.1	66.5		94.7	94.1	93.6	92.7
Conventional	64.8	66.5	64.7	65.6		94.8	93.8	93.8	94.0
Strobilurin	64.1	65.3	65.6	65.9		95.4	94.4	94.0	93.7

2. Caythorpe

a) Yields and specific weights

Applied N:	75 kg/ha	100	125	150		75 kg/ha	100	125	150
	Yield (t/ha)					**Specific weight (kg/hl)**			
Variety/F programme									
Optic									
Untreated	4.49	4.84	4.78	5.41		64.8	64.4	64.4	65.3
Conventional	4.63	5.21	5.63	5.69		64.3	64.8	64.8	65.6
Strobilurin	5.17	5.64	5.67	5.92		64.9	65.3	65.4	65.4
Chariot									
Untreated	4.35	4.71	4.60	5.32		62.7	64.7	64.7	65.7
Conventional	4.24	5.00	5.31	5.49		64.5	64.3	65.1	65.2
Strobilurin	4.92	5.39	5.54	5.67		64.0	64.9	65.6	65.3
Decanter									
Untreated	4.31	5.10	4.97	5.51		63.7	63.3	64.6	63.4
Conventional	4.63	5.37	5.81	5.63		63.8	63.5	64.2	64.6
Strobilurin	4.85	5.31	5.74	5.98		64.0	64.2	64.2	64.1

b) Grain nitrogen (%) and screenings > 2.5mm

Applied N:	75 kg/ha	100	125	150		75 kg/ha	100	125	150
	% grain nitrogen					**% screenings >2.5mm**			
Variety/F programme									
Optic									
Untreated	1.46	1.46	1.55	1.68		95.9	96.3	96.1	96.3
Conventional	1.47	1.53	1.61	1.78		97.0	96.8	97.7	96.1
Strob	1.48	1.63	1.60	1.65		96.8	97.3	97.0	96.5
Chariot									
Untreated	1.43	1.52	1.73	1.86		97.0	97.1	96.8	97.1
Conventional	1.55	1.63	1.72	1.81		96.8	97.3	97.1	97.1
Strob	1.59	1.64	1.74	1.80		98.0	97.5	97.5	97.1
Decanter									
Untreated	1.44	1.55	1.66	1.79		96.3	96.8	95.4	96.6
Conventional	1.58	1.55	1.68	1.82		97.0	97.5	95.8	95.8
Strobilurin	1.55	1.61	1.71	1.88		97.0	97.4	96.6	96.4

3. Morley

a) Yields and specific weights

Applied N:	75 kg/ha	100	125	150		75 kg/ha	100	125	150
	Yield (t/ha)					**Specific weight (kg/hl)**			
Variety/F programme									
Optic									
Untreated	4.38	4.73	5.05	5.61		66.8	66.9	66.3	66.1
Conventional	4.86	5.57	5.83	5.92		65.7	66.9	67.0	66.9
Strobilurin	5.07	5.66	6.08	6.55		66.4	66.8	66.7	67.7
Chariot									
Untreated	4.75	4.94	5.27	5.11		68.3	68.5	68.8	68.6
Conventional	4.72	5.24	5.35	5.49		67.9	68.9	68.6	68.9
Strobilurin	4.92	5.33	5.46	5.59		68.1	68.6	69.0	68.9
Decanter									
Untreated	4.72	4.81	5.14	5.33		67.2	67.2	67.4	67.3
Conventional	4.65	5.57	5.57	6.1		66.9	67.5	67.4	67.4
Strobilurin	5.03	5.73	5.7	6.15		67.1	67.6	67.3	67.8

b) Grain nitrogen (%) and screenings > 2.5mm

Applied N:	75 kg/ha	100	125	150		75 kg/ha	100	125	150
	% grain nitrogen					**% screenings >2.5mm**			
Variety/F programme									
Optic									
Untreated	1.75	1.77	1.84	1.89		96.2	95.7	95.4	95.8
Conventional	1.77	1.81	1.88	1.92		95.1	95.7	96.2	95.8
Strob	1.75	1.76	1.88	1.96		97.2	96.7	95.7	97.4
Chariot									
Untreated	1.68	1.59	1.85	1.86		94.3	94.6	94.8	95.7
Conventional	1.56	1.61	1.76	1.92		96.4	95.0	95.8	93.5
Strob	1.63	1.65	1.82	1.92		96.2	95.3	95.3	94.6
Decanter									
Untreated	1.59	1.66	1.65	1.82		91.4	89.3	91.0	91.7
Conventional	1.64	1.84	1.72	1.84		94.9	94.8	92.5	94.6
Strobilurin	1.54	1.65	1.86	1.92		95.3	94.8	94.4	96.0

10. Cirencester

a) Yields and specific weights

Applied N:	Yield (t/ha) 75 kg/ha	100	125	150		Specific weight (kg/hl) 75 kg/ha	100	125	150
Variety/F programme									
Optic									
Untreated	4.6	4.87	4.95	5.65		66.6	65.7	66.7	67.0
Conventional	4.47	5.08	4.98	5.62		66.3	67.1	66.7	68.7
Strobilurin	4.71	5.32	5.37	5.78		65.9	67.3	67.7	68.0
Chariot									
Untreated	4.24	4.58	4.95	5.47		66.1	66.2	65.6	66.7
Conventional	4.47	4.6	5.3	5.51		65.5	66.7	66.5	68.7
Strobilurin	4.58	4.79	5.4	5.79		65.3	66.3	67.0	67.5
Decanter									
Untreated	4.16	4.73	5.07	5.51		65.9	67.3	67.7	66.1
Conventional	4.51	4.85	5.26	5.80		66.2	67.8	66.2	67.9
Strobilurin	4.59	4.73	5.36	5.78		66.6	67.7	67.6	67.7

b) Grain nitrogen (%) and screenings > 2.5mm

Applied N:	% grain nitrogen 75 kg/ha	100	125	150		% screenings >2.5mm 75 kg/ha	100	125	150
Variety/F programme									
Optic									
Untreated	1.42	1.38	1.51	1.70		98.0	97.7	98.0	98.0
Conventional	1.46	1.47	1.57	1.71		98.1	98.2	98.6	95.0
Strob	1.41	1.46	1.47	1.57		97.8	98.3	98.4	98.4
Chariot									
Untreated	1.50	1.54	1.66	1.80		97.8	97.8	96.7	97.0
Conventional	1.52	1.56	1.72	1.81		97.8	97.3	97.6	98.0
Strob	1.49	1.54	1.67	1.84		97.8	97.6	97.8	97.9
Decanter									
Untreated	1.52	1.51	1.68	1.56		97.2	95.5	96.1	93.7
Conventional	1.53	1.62	1.64	1.71		97.3	96.7	96.8	95.8
Strobilurin	1.52	1.52	1.70	1.59		97.6	96.8	97.3	97.4

Appendix 2. Net margin calculations

Prices used in net margin calculations:

Grain price (feed)	£60/tonne
Grain price (malt)	£76/tonne
Fertiliser costs:	
Nitrogen	£0.37 /kg N
Fungicide costs:	
Opus	£22/ litre
Corbel	£20/ litre
Amistar	£32/ litre